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ORIGINAL ARTICLES.

I.—The Skull of *Protoceras*.

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PLATE XIX.

THE genus *Protoceras*, described by the writer in 1891, from the Miocene of South Dakota, is now known to include some of the most interesting extinct mammals yet discovered. It likewise represents a distinct family, and thus deserves careful investigation and description.[1] Before this discovery, no horned artiodactyles were known to have lived during Miocene time, and *Protoceras* is thus the earliest one described. The type-specimen, moreover, had a pair of horn-cores on the parietals, and not on the frontals as in modern forms of this group. The animal was apparently a true ruminant, nearly as large as a sheep, but of more delicate proportions.

The first skull found, the type-specimen of the genus *Protoceras*, belonged to a female, as later discoveries demonstrated. The skull of the male proved still more remarkable, and especially resembles the male skull of the Eocene Dinocerata in having several pairs of horn-cores or protuberances upon the head, a feature hitherto unknown among the Artiodactyla. It is an interesting fact, moreover, that one pair of these horn-cores of *Protoceras* is on the maxillaries, as in *Dinoceras*, while the posterior pair, as in that genus, is on the parietals.

The resemblance in the two skulls is further enhanced by the absence of upper incisors and the presence of large canine tusks, forming together a striking similarity in important features, between skulls pertaining to animals of two distinct orders, and from widely different geological horizons. The skull of the male *Protoceras* is shown in Plate XIX, and that of *Dinoceras* in the text below.

It is a noteworthy fact, that in still another order of ungulate mammals, the Perissodactyla, horn-cores in pairs early made their appearance, although none are known in the recent forms. One of the earliest instances is seen in the genus *Colonoceras* from the Middle Eocene, which had rudimentary protuberances upon its nasal

[1] American Journal of Science, vol. xli, p. 81, January, 1891; vol. xlvi, p. 407, November, 1893; and vol. iv, p. 165, September, 1897.

Skull of Male of *Protoceras celer*, Marsh.
Upper Miocene; South Dakota, U.S.A.
Three-fourths natural size.

bones. The gigantic Brontotheridæ of the Lower Miocene all had prominent horn-cores on the maxillary bones, somewhat like those of the male *Protoceras*. One of the most unexpected examples, however, in this order, appears in the Miocene genus *Diceratherium*. This animal, although a true rhinoceros, had a pair of horn-cores on the nasal bones, while all other rhinoceroses, living and extinct, are

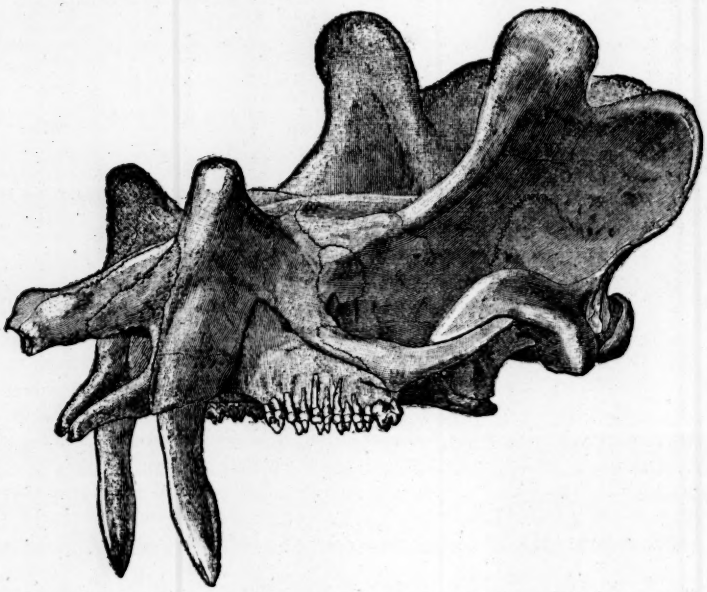

Fig. 1.—Cranium of *Dinoceras mirabile*, Marsh. Type; seen from the side. One-seventh natural size. Middle Eocene: Wyoming Territory, U.S.A.

either without horns or have them on the median line. In short, horns in pairs are unknown in existing mammals, except in the artiodactyles, an order of later development, but now the dominant group of ungulate mammals.

The Skull of the Male.

The skull of the male *Protoceras*, in addition to the marked characters above mentioned, has others of equal interest, if not of still greater taxonomic value. The general appearance of the adult male skull is well shown in Plate XIX, accompanying the present article.

Aside from the various horn-cores and protuberances upon the skull, the next most notable feature is the very large, open nasal cavity, a character which pertains to both sexes, and to the entire family of the Protoceratidæ. This peculiar feature is of even more importance than the horn-cores, judging from its functional significance, and its rarity in more recent forms of artiodactyles. It indicates clearly in the living animal a long flexible nose, if not

a true proboscis. The only existing ruminant thus equipped, known to the writer, is the rare Saiga antelope (*Saiga Tartarica*, Gray) from the steppes of Siberia. A comparison of a *Protoceras* skull with that of the Saiga antelope plainly indicates, in the nasal region, an identity of function doubtless accompanied by a similar nasal appendage, and it is of interest to find such evidence of this feature in a representative from the Miocene of North America.

The general form of the male skull of *Protoceras* is long and narrow, with the facial portion much produced. The prominent horn-cores, however, serve to obscure its real shape, which is more apparent in the female skull. Seen from the side, as in Plate XIX, it appears unusually low, with the orbit well behind. Its greatest width is in the posterior region.

The premaxillaries are small and edentulous. Their anterior extremities are depressed, and more or less expanded transversely, as in typical ruminants. The outer suture between the premaxillary and maxillary is short, and persistent even in adults. Seen from below, the premaxillaries form together the palatal surface in front of the maxillaries, each sending backward a narrow process which is inserted between the divergent maxillary plates. The anterior palatine, or incisive, foramina are situated on the sutures separating the two bones.

The maxillary bones are greatly developed, being much the largest elements of the skull, as shown in Plate XIX. The anterior extremity supports the large descending canine tusk, and is hollowed out to contain its base. The high anterior horn-cores are formed entirely of the maxillary bones, which are greatly strengthened to support them. These horn-cores are more or less recurved, and in the type-species their summits are triangular in outline. In another species, *Protoceras nasutus*, the summits of the maxillary horn-cores are oval in section. Another characteristic feature of the genus *Protoceras*, which is seen in both sexes, is a strong lateral ridge extending nearly horizontally across the outer face of the maxillary bone, and continuing backward to the orbit. In the male skull here described, this ridge begins near the base of the maxillary horn-core, and, expanding into a prominent tubercle, just above the antorbital foramen, continues backward by an upward curve, and passes into the ridge of the malar bone extending beneath the orbit. In both sexes, the anterior portion of this lateral ridge, with its characteristic tubercle, forms the lower border of a deep, well-marked depression, which probably contained a gland. In Plate XIX this cavity is well shown behind the maxillary horn-cores, just below the point where the superior border of the skull is lowest.

The nasal bones join the maxillaries above, and complete the posterior border of the large narial opening. They are of moderate length on the median line, and their free anterior extremities are quite short. These bones are much expanded transversely, and at their widest part articulate with the lachrymals. All the sutures surrounding the nasals are distinct, and this is true also of their median suture. Their upper surface is convex, both transversely

and longitudinally, and is marked by two deep grooves, which lead backward to the supra-orbital foramina in the parietals.

The frontals, which bound the nasals behind, are large massive bones, much wider than long. The suture which unites the two frontals is distinct, and cuts the naso-frontal suture nearly at right angles. At the lateral junction of the frontal and nasal, there is on each side a low tuberosity, resembling a diminutive horn-core, and these form the third pair of elevations on the skull. At the postero-external angle of the frontals, above the orbits, another pair of much larger protuberances is seen, and the summits of these are widely expanded transversely. The upper surface of the frontals is rugose, and the deep grooves already mentioned are characteristic features.

The parietal bones are much smaller than the frontals, and are separated from them by a distinct sigmoid suture. These bones support the posterior pair of horn-cores. The general form and position of these elevations on the male *Protoceras* skull are represented in the accompanying plate, but they differ in each species. Behind these horn-cores there is a low sagittal crest separating the deep temporal fossæ. Back of the parietals is the short supra-occipital, which forms a weak lambdoidal crest bounding the temporal fossæ behind.

The inferior portion of each fossa is formed by the squamosal, which covers the lower half of the brain-case, and joins the parietal above by a distinct suture, as shown in Plate XIX. The squamosal sends forward a short zygomatic branch, which fits into a notch in the posterior part of the malar. There is a distinct postglenoid process. The tympanic bone is not dilated into a definite bulla, but below the auditory meatus forms a short descending process. The periotic is behind the tympanic, separated from it above by the post-tympanic process of the squamosal, and below by an open suture. It is wedged in between the latter bone and the strong and elongate paroccipital process of the exoccipital.

The orbit is closed behind by a descending process from the frontal, which meets the upper branch of the malar. Its lower border is bounded by the malar, which in front joins the lachrymal above and the maxillary below, as shown in Plate XIX.

The lachrymal is bounded in front by the maxillary, above by the nasal and frontal, and below by the malar and maxillary. The lachrymal foramina are two in number, well within the orbital border. The orbits are large, suboval in outline, and widely separated from each other. Their posterior position is a characteristic feature of the genus *Protoceras*.

The Base of the Skull.

The narrow occiput, surmounted by the supra-occipital, is a noteworthy character. The widely expanding orbits greatly increase the width of the skull in this region, and from here forward its wedge-like shape is a striking feature. The basi-occipital and the basisphenoid bones are firmly co-ossified, the suture between them being indistinct. In front of the latter bone is the parasphenoid,

separated from it by a well-marked suture, and passing forward above the vomers, which are here distinct. The pterygoids are attached to the posterior border of the palatines, and above to the alisphenoids. There is no distinct alisphenoid canal.

The palatine bones are narrow, and bound in front the posterior nares, which extend forward to near the middle of the penultimate molars. The maxillary plates form the roof of the palate forward to the premaxillaries. At their narrowest portion, they are deeply grooved for the approaches of the palato-maxillary foramina, which are situated somewhat in advance of the second premolars. The maxillary plates are separated in front along the median line, to receive the posterior branches of the premaxillaries, and on the suture between the two elements the anterior palatine foramina are in their usual position. The turbinal bones were apparently quite small.

The Lower Jaw.

The lower jaw is well represented in Plate XIX. It is long and slender, especially in front, thus corresponding to the skull. The condyle is broad and strongly convex above. The coronoid process is very short, and its summit is but little higher than the condyle. The angle is rounded and well developed. The ramus expands downward and is thickened beneath the molar teeth, and has a sharp upper edge along the diastema between the first and second premolars. It again extends downward at the symphysis, becoming more robust to support the front teeth.

The Dentition.

The dentition of *Protoceras* is of the early ruminant type, as shown by the short-crowned, selenodont molar series. The dental formula is as follows:

$$\text{Incisors } \tfrac{0}{3},\ \text{Canines } \tfrac{1}{1},\ \text{Premolars } \tfrac{4}{4},\ \text{Molars } \tfrac{3}{3}.$$

In the male skull, the upper canines are well developed, as shown in Plate XIX. They are compressed and somewhat trihedral in transverse section, and in life formed efficient weapons of warfare. The first upper premolars, a short distance behind, are small compressed teeth, each with two roots; and after a still longer diastema, the second premolars begin the continuous series. The second and third upper premolars each have a large outer cusp and an inner cingulum, while the fourth has a distinct inner crescent. The superior molars have all short crowns and the double crescents of true selenodont dentition, with a well-developed inner basal ridge.

The teeth of the lower jaws of *Protoceras* are indicated in Plate XIX, and the full series is shown. The three incisors are directed well forward, and diminish in size from the first to the third. The still smaller canine is situated close to the last incisor, and is similar in form. A long diastema follows, and gives the upper canine freedom of motion. The first premolar is somewhat similar to the corresponding one above, but is larger and directed

more forward. A still longer interval separates the first and second lower premolars, the latter beginning the continuous molar series. The second premolar has the crown much compressed, while the third and fourth are triangular in form. The three true molars have the usual crescents corresponding to those above, but no inner cingulum.

The Cranium of the Female.

The type-species of the genus *Protoceras*, as already stated, was the skull of a female, and it may be well to repeat here its essential features as given in the original description already cited. In Fig. 2 below, most of the main characters of this type-specimen are represented.

"In general form and proportions, this skull is of the ruminant type. Its most striking feature is a pair of small horn-cores, situated, not on the frontals, but on the parietals, immediately behind the frontal suture. These prominences were thus placed directly over the cerebral hemispheres of the brain.

"The frontal bones are very rugose on their upper surface, and this rugosity extends backward on the parietals, and to the summit of the horn-cores, as well as between the latter, and along the wide sagittal crest. The horn-cores are well separated from each other, and point upward, outward, and backward, overhanging somewhat the temporal fossæ. They are conical in form, with obtuse summits.

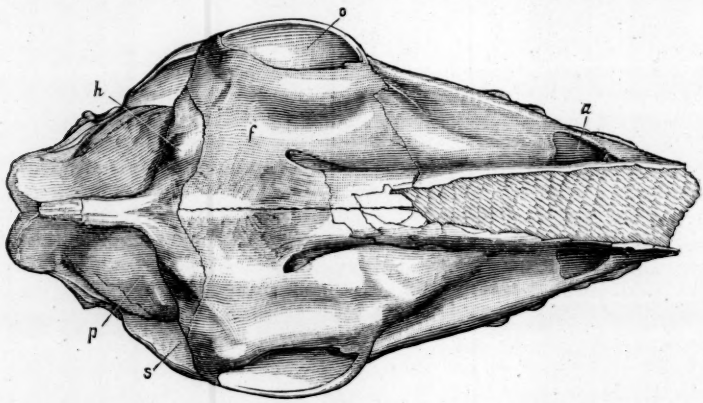

FIG. 2.—Cranium of *Protoceras celer*, Marsh; seen from above. One-half natural size. *a*, depression in maxillary; *f*, frontal; *h*, horn-core; *o*, orbit; *p*, parietal; *s*, suture between frontal and parietal. Miocene: South Dakota.

"Between the orbits, the frontals are depressed, and marked by two deep grooves leading backward to the supra-orbital foramina. Behind these, half-way to the horn-cores, is a median prominence resembling in shape the corresponding elevation on the skull of the male giraffe. The brain cavity is unusually large for a Miocene mammal. The occiput is very narrow, indicating a small cerebellum, and the occipital crest is weak. The occipital surface slopes backward.

"The facial region of the skull is narrow and elongate. On the outer surface of the maxillary, just above the antorbital foramen, there is a deep depression, which probably contained a gland. The usual ruminant fossa in front of the orbit appears to be wanting. The orbit is large, and completely closed behind by a strong bar of bone.

"The dentition preserved is selenodont and brachyodont, with only three premolars and three molars.[1] The first premolar is much compressed transversely, and has but a slight inner lobe. The second premolar is triangular in outline, the inner lobe being much more developed. The last premolar has this lobe expanded into a strong cusp, and the crown thus becomes broader than long. The true molars have two inner cusps, each with a basal ridge. The outer crescents have a median vertical ridge. The enamel of the molar series is more or less rugose. There was a wide diastema in front of the premolars.

"The posterior nares are situated far forward, the anterior border being opposite to the posterior cusp of the second true molar. The glenoid facet is large and convex, but the postglenoid process is quite small. The paroccipital processes were well developed, but there were apparently no auditory bullæ."

A number of other female skulls, some of them in excellent preservation, have since been obtained from the same region in which the type was found, and a study of these makes clear the main points of their structure. It is not quite certain to which of the three species of *Protoceras* now known some of these skulls should be referred, but further investigation will doubtless determine this point, as the present material in the Yale Museum is apparently sufficient for this purpose.

All the known remains of *Protoceras* are from the Upper Miocene of South Dakota. The horizon, which is a definite one, has been appropriately called by Dr. Wortman the *Protoceras* beds. They appear to be identical with the series in Oregon, which the writer had previously named the *Miohippus* beds, as that genus and several others are common to both regions.

EXPLANATION OF PLATE XIX.

Skull of the male of *Protoceras celer*, Marsh; oblique side view. Three-fourths natural size. Miocene: South Dakota, U.S.A.

II.—William Smith's Manuscript Maps.

By Professor J. W. Judd, C.B., LL.D., F.R.S., F.G.S., etc.

IT is well known to all students of the history of geology that, although the date of publication of William Smith's "Map of the Strata of England and Wales" was the year 1815, yet even before the commencement of the present century the "Father of English Geology" had not only established the principle that strata can be identified by their organic remains, but had actually applied that

[1] More perfect specimens since discovered prove that there were four premolars, the first being absent in the type.

important principle in the construction of a number of geological sections and maps. Conclusive documentary evidence of the truth of this statement is fortunately in the possession of the Geological Society. The way in which these important documents were acquired by the Society is well known to all geologists. When the Wollaston Medal was founded, it was unanimously resolved by the Council of the Geological Society (January 11, 1831)—

"That the first Wollaston Medal be given to Mr. William Smith, in consideration of his being a great original discoverer in English Geology; and especially for his having been the first, in this country, to discover and to teach the identification of strata, and to determine their succession by means of their imbedded fossils."

To the lucid historical statement in which the President of the Society—Professor Adam Sedgwick—explained and justified this award, William Smith replied in "a short and manly speech," which he concluded by presenting to the Society "some documents referred to in the President's address." These documents were as follows:—

1. A table of the Order of Strata, and their imbedded Organic Remains, in the vicinity of Bath; examined and proved prior to 1799.

2. A map of the country five miles round Bath, on the scale of one and a half inches to the mile. "Coloured geologically in 1799, by William Smith."

3. The first draft of a geological map of England and Wales, entitled "General Map of Strata found in England and Wales, by William Smith, surveyor, 1801."

The careful reader of the historical statements drawn up by Fitton,[1] Sedgwick,[2] and Phillips,[3] will be satisfied that other and still earlier documentary evidence, in the form of manuscript sections and maps, once existed, and had been examined by those authors. But it is highly probable that by the year 1831 all such manuscripts, which could be regarded as important pieces of evidence, had been given away or lost by William Smith, with the exception of the three presented by him to the Geological Society. At all events, I fear that the chance of the recovery of any such manuscripts of William Smith, is now a remote one. Twenty-five years ago, the late Mr. W. Stephen Mitchell set himself the task of hunting for relics of the Father of English Geology in Bath and elsewhere. I was at the time in frequent communication with Mr. Mitchell, who was able to take counsel with John Phillips and other contemporaries of William Smith, then living and able to direct him in his inquiries; but I gathered that these investigations were fruitless, and that though

[1] The Edinburgh Review, February, 1818; the London and Edinburgh Philosophical Magazine, vol. i, pp. 147–60, 268–75, 442–50; and vol. ii, pp. 37–57, (1832–3).

[2] Proceedings of the Geological Society (1831), pp. 270–80.

[3] Memoirs of William Smith, Author of "The Map of the Strata of England and Wales," 1844.

many biographical details of interest were collected by Mr. Mitchell, yet that no fresh manuscripts of Smith were found to reward his labours.

This being the case, the three documents in the possession of the Geological Society must be regarded of the very highest importance and of priceless value. They have been mounted on linen and framed, and have never left the custody of the officers of the Geological Society, except in the year 1876, when they were exhibited for some months at the Loan Collection of Scientific Apparatus in the South Kensington Museum.

As it appeared to me that this valuable evidence of the early work of William Smith ought to be made more accessible to the general public, while it is manifestly desirable that the precious originals themselves should never leave the custody of the Society, or be subjected to the smallest risk of loss or injury, I sought some time ago (on behalf of the Department of Science and Art) the permission of the Council of the Geological Society to have facsimile copies made of these important documents, for exhibition in the Science Museum at South Kensington, among the illustrations of British and Foreign Geological Maps.

This permission having been generously granted to me, I have taken the opportunity of making a careful and critical examination of the documents, the age and value of which are substantiated by such eminently satisfactory external and internal evidence.

It is obvious from an inspection of these manuscripts, that they have been many times folded and unfolded, and probably carried in a pocket or pocket-book, and that at the time they were mounted they were in a state of extreme dilapidation. Unfortunately, as is now only too evident, the manuscripts, after being pasted on linen mounts, were covered with a coating of varnish, which was very unevenly applied. This varnish, which has turned perfectly yellow with age, renders it very difficult to get good photographic reproductions of the documents, or to be quite certain, in some cases, as to the nature and distribution of the colours upon them. The removal of the varnish would have been attended with risk to the water-coloured maps; I therefore had to be satisfied with the best reproductions that could be obtained by the skilled photographer of the Department of Science and Art, and these were carefully coloured, after the originals, by Miss Margaret Reeks, under my superintendence. In the choice of colours we were guided to some extent by the later published maps and sections of William Smith, for it is evident that in many of his methods he was very conservative. It is hoped that these facsimiles, though they are not so good as could have been made from manuscripts in a less permanently discoloured condition, show all the important features of the documents as they originally left the hands of their author.

Four sets of these facsimile reproductions have been prepared. One set is exhibited in the rooms devoted to Geology and Mineralogy in the Science Museum at South Kensington; a second set is placed in the Library of the Geological Society; a third goes to the

Geological Department of the Natural History Museum at Cromwell Road, South Kensington; and a fourth to the Library of the British Museum at Bloomsbury.

The origin of the first of the three documents of the series has been admirably told by Phillips in his "Life of Smith" (p. 29).

"One day, after dining together at the house of the Rev. Joseph Townsend" (29, Pulteney Street, Bath), "it was proposed by one of this triumvirate" (Smith, Richardson, and Townsend) "that a tabular view of the main features of the subject, as it had been expounded by Mr. Smith, and verified and enriched by their joint labours, should be drawn up in writing. Richardson held the pen and wrote down, from Smith's dictation, the different strata according to their order of succession in descending order, commencing with the Chalk, and numbered, in continuous series, down to the Coal, below which the strata were not sufficiently determined. To this description of the strata was added, in the proper places, a list of the most remarkable fossils which had been gathered in the several layers of rock. The names of these fossils were principally supplied by Mr. Richardson, and are such as were then, and for a long time afterwards, familiarly employed in many collections near Bath. Of the document thus jointly arranged, each person present took a copy,[1] under no stipulation as to the use which should be made of it, and accordingly it was extensively distributed, and remained for a long period the type and authority for the descriptions and order of superposition of the strata near Bath."

The table in the possession of the Geological Society is in the handwriting of Richardson, but bears the following attestation written by Smith himself:

"This table of the strata, dictated by myself, is in the handwriting of the Rev. Benjamin Richardson, and was first reduced to writing at the house of the Rev. Joseph Townsend, Pulteney Street, Bath, 1799.—Wm. Smith."

"This very curious and important document," as Sedgwick pointed out, "was the first tabular sketch of our formations, drawn up before William Smith had, in conjunction with Mr. Richardson, finally decided upon the names by which they ought to be designated; and the successive groups, from the Coal-measures to the Chalk inclusive, are represented by a series of numbers, accompanied with explanatory notes, but without any proper names affixed to them."[2]

As full transcripts of this table have been published by both Fitton[3] and Phillips,[4] it will be sufficient here to indicate the several divisions then recognized by Smith with the names by which they were subsequently known.

[1] According to a written statement of William Smith, published by Fitton, a copy of the document was, at the time it was drawn up, given to William James, Esq.

[2] Proc. Geol. Soc., vol. i (1831), p. 276.

[3] Phil. Mag., vol. ii (1833), pp. 46, 47.

[4] "Life of Wlliam Smith," p. 30.

1. Chalk, 300 feet (Chalk, Upper and Lower).
2. Sand, 70 feet (Firestone, Upper Greensand).
3. Clay, 30 feet (Gault).
4. Sand and Stone, 30 feet (Portlandian or Cornbrash?).
5. Clay, 15 feet (Bradford Clay?).
6. Forest Marble, 10 feet (Forest Marble).
7. Freestone, 60 feet (Great or Bath Oolite).
8. Blue Clay, 6 feet
9. Yellow Clay, 8 feet
10. Fuller's Earth, 6 feet
11. Bastard ditto and sundries

} Fuller's Earth Series.

12. Freestone, 30 feet (Inferior Oolite).
13. Sand, 30 feet (Midford Sand).
14. Marle Blue, 40 feet
15. Lias Blue, 25 feet

} Lias.

16. Lias White, 15 feet
17. Marlestone Indigo and Black Marle, 15 feet

} Rhætic.

18. Red-ground, 180 feet (Trias).
19. Milstone
20. Pennant Stone
21. Grays
22. Cliff
23. Coal

} Carboniferous.

The absence of distinctive names to the strata, with the inadequate thicknesses assigned to some of them, and some minor errors as to the order of succession, afford sufficient evidence, if this were needed, that the document is really of the early date which it bears.

The second document in this series is even more interesting, as it may be justly regarded as the oldest *geological* map in existence, if we distinguish geological from agricultural or soil maps. We cannot do better than tell its history in Smith's own words—

"During my five years' close confinement" (1794–99) "to practical engineering on the Coal Canal, my much-wished-for opportunity of collecting observations enough from the ranges of the different strata to make an accurate delineation of the stratification throughout England were suspended."

But after his connection with the Coal-Canal works had ceased, Smith adds—

"I drew in colours, on a map of the vicinity of Bath and on Day and Masters' County Survey, all very accurately to a certain extent, which embraced an interesting but intricate variety of strata in hills around Bath."[1]

The geologically coloured copy of Day and Masters' Map of Somersetshire (on the scale of one inch to a mile) was publicly exhibited and explained by Smith at an annual Agricultural Meeting at Bath in the year 1799. This map unfortunately has been lost, but the Map of the Vicinity of Bath is one of the documents

[1] Phillips' "Life of William Smith," p. 27.

preserved by the Geological Society. It bears the inscription in Smith's handwriting:

"Presented to the Geological Society, Feb. 18th, 1831.
Wm. Smith.
Coloured Geologically in 1799."

The basis of this geological map is of circular form and 15 inches in diameter. It is entitled: "A Map of Five Miles round the City of Bath, on a scale of one inch and a half to a mile, from an Actual Survey, including all the New Roads, with Alterations and Improvements to the present time, 1799." "Printed for and sold by A. Taylor and W. Moyler, Booksellers, Bath."

Although this map includes only a very small area, it presents many features of great interest. In the first place, it shows that William Smith was aware of the importance of representing upon maps the actual limits between the outcrops of different strata. Though no lines are drawn, Smith's well-known method of colouring the base of a formation with a deep tint, and shading this upwards towards the outcrop of the next overlying stratum, enables us to see how carefully he had mapped all the geological lines around Bath. There are only three colours employed on the map and no index; but it is evident that the yellow tint represents the Bath Oolite, the base of the freestones being very accurately mapped, so that even the smallest outliers can be made out agreeing most closely with the map of the Geological Survey; a blue tint is drawn at the base of the Lias, and a red one at the base of the Trias, the inliers of Carboniferous being left blank. How far William Smith was in advance of his contemporaries, is shown by a comparison of this map of William Smith, showing carefully indicated lines of outcrop, with the excellent map of the Environs of Paris by Cuvier and Brongniart (1809), in which colour is spread over the areas occupied by the several formations, without any clear and definite indications of the actual limits of the outcrops. The colours used by Smith in this map were the same as those employed by him in the later maps of 1801 and 1815, and thus we have in it the first indication of a scheme of colour now very generally adopted by geologists.

The third and most important of these documents is a copy of Carey's Index to the Map of England, coloured geologically. The map is eleven inches high by nine inches in breadth, and has the manuscript title, "General Map of Strata found in England and Wales, by Wm. Smith, Surveyor, 1801." On the side of the map is written, "Wm. Smith, Milford, near Bath," and at the bottom, "Presented to the Geological Society by Wm. Smith, Feb. 21, 1831," all the inscriptions being in Smith's own handwriting.

Before considering the geological information which is furnished by this map, it will be interesting to recall the opportunities which Smith really had of making himself acquainted with the positions of the outcrops of the English strata. When between 12 and 13 years of age (in 1781), Smith paid a visit to London, and appears

to have been greatly struck by an exposure of the Chalk in a road-cutting at Henley. In 1787, when 18 years of age, he was apprenticed to Edward Webb, and, as he himself says, "was employed in the survey of estates and the inclosure of extensive commons and open fields in the counties of Oxford, Warwick, Worcester, Gloucester, Wilts, Hants, and Somerset, which embraced all the strata, from the red marl at Inkborough and Rugby, near Alcester, to the sand and gravel over chalk at Dibden, between the New Forest and Southampton."

When Smith settled in Somersetshire in 1791, he was familiar with "the surface of the country from London to Bath, and from Warwick to Southampton"; and during his surveys at Stowey and the High Littleton Collieries (1791–2) he not only found fresh evidence of his views about the superposition and continuity of the several strata, but detected the unconformity between the Secondary strata and the underlying Carboniferous rocks. In 1793, while taking levels for the Somersetshire Coal Canal, he "proved the red marl, lias, blue marl, and inferior oolite on the tops of the highest hills to be generally inclined towards the east; and this notion of a general declination appeared to hold through all the varieties of strata in the considerable extent of country before noticed; and other levels down two parallel valleys in the same strata seemed further to confirm the same notion." In 1794 Smith made a post-chaise journey of 900 miles—from Bath to Newcastle-on-Tyne by one route, and back again by another—and was able to satisfy himself that the order of succession which he had made out in the south-west of England could be applied to the whole of the country. During the period that Smith was resident engineer to the Somersetshire Coal Canal (1793–9), he not only worked out the minute details of the order of succession of the Jurassic rocks in the district, but finding difficulty in identifying the several Jurassic strata—owing to the resemblances between the several clays and oolitic limestones on different geological horizons—he was led to the great discovery with which his name will ever be associated. In Smith's own words: "Doubts were at length removed by a more particular attention to the site of the organized fossils, which I had long collected. This discovery of a mode of identifying the strata by the organized fossils respectively imbedded therein—the sharpness of those in their primitive sites, contrasted with the same fossils rounded and water-worn in gravel—led to the most important distinctions, which at once seemed to clear away the rubbish and common stumbling-blocks in geology."

It will thus be seen that at the date when Smith prepared the manuscript geological map of England, he had minutely surveyed the Jurassic strata and Carboniferous rocks of Somersetshire, and gained a wide but much more general knowledge of all the strata, from the Chalk to the Coal-measures inclusive, over an area extending from Warwickshire and the Bristol Channel on the west to London and Southampton on the east. Outside this area, Smith's knowledge of the country was derived from his post-chaise journey

to the north, supplemented by persevering inquiries in every quarter where he could hope to glean information.

The idea of a general geological map of England appears to have been generated in the mind of William Smith upon the occasion of the famous post-chaise journey in 1794; but during his five years' close confinement to practical engineering on the Coal Canal, his much-wished-for opportunities of collecting observations enough from the ranges of the different strata to make an accurate delineation of the stratification throughout England were, as we have already seen, suspended.

The leisure which followed his resignation of the post of Resident Engineer to the Coal Canal was spent by Smith in endeavouring to carry out his great scheme. He says that he "wasted much time in poring over maps, in contriving how the ranging edges and planes of the different strata could best be rendered intelligible; models were thought of, and one small map was cut along the edges of some of the strata with a view of defining their extent, and of showing how one stratum was successively covered by another." He adds that "some small maps of England were spoiled by speculating on the ranges of stratification without sufficient data. The intricacies in their marginal edges were such that I found, to mark point by point, as the facts were ascertained, was the only way in which I could safely proceed."

The result of Smith's speculations as to the best way of representing the outcropping strata upon maps is seen in the method which he finally adopted, and which was first illustrated in the manuscript maps of 1799 and 1801. The *base* of each formation is shown by a band of colour which is shaded upwards towards the next succeeding formation. The colours adopted in the manuscript geological map of England and Wales of 1801 appear to have been very similar to those used in Smith's later engraved maps.

There is nothing in the way of an index of colours attached to this first geological map of England and Wales, but, by reference to the author's later publications, it is not difficult to determine what the several bands of colour are intended to indicate. The formations of which the outcrops are represented range from the Chalk to the Old Red Sandstone, the colours employed being eight in number, though a number of other signs, indicating collieries, mines, and slate-quarries, adds much to the valuable information supplied by this remarkable map.

The strata represented are, in descending order, as follows:—

1. Chalk (*green*).
2. "Sand of the Portland Rock," with which is confounded (as in later maps) the Carstone of Norfolk (*purple*).
3. Oxford Clay ("Church Clay" of Smith) (*grey*).
4. Oolite. The outcrop represented is that of the Great Oolite of the Bath area, and of the Inferior Oolite both south and north of that area (*yellow*).
5. Lias (*dull blue*).
6. Trias and Permian ("Red Marl" of Smith) (*light red*).

7. Carboniferous Limestone, with which is confounded the Magnesian Limestone (*bright blue*).
8. Old Red Sandstone (*reddish-brown*).

The distribution of the Coal-measures is indicated by the crowding together of the crosses representing collieries; the position of the slaty rocks by marks standing for slate-quarries; while a few mines are represented in the North of England, Wales, and Derbyshire, but none in Cornwall!

The east coast of Great Britain has been roughly continued by a manuscript line as far as Forfarshire, the name "Redhead" being written nearly in the position of Arbroath. Collieries are represented near Edinburgh, a colliery and limestone, with the words "Coal 9 yards thick," in the South of Fife, and limestone in Forfarshire. Where the west coast of Scotland would appear we have in Smith's handwriting "Slate, etc., Eysdale Island, Isle of Bute." In the Isle of Man patches of colour indicate the limestones of Castletown and the red sandstones of Peel.

While this first sketch of a geological map is remarkable for the accuracy with which the main outlines of the geological structure of the country are represented, certain omissions and errors are noteworthy as affording the clearest evidence that the map was actually constructed at the date written upon it (1801), and that it had no additions made to it at a later date.

The absence of any colouring for the Tertiary strata of East Anglia and the London and Hampshire Basins, for the Wealden area, and for the Jurassic district of the Eastern Moorlands of Yorkshire, are especially striking in this connection. It can be shown that in the years immediately following 1801, Smith had opportunities, which he utilized with more or less success, in obtaining information concerning these three districts, but no trace of knowledge concerning them appears on the map. Yet of his industry and ingenuity in bringing together every fact which could aid him in the construction of the map of 1801 we have abundant proofs. The Yorkshire Wolds were only seen by him from the top of York Minster and recognized by their contour, yet the range of the Chalk is well represented in Yorkshire and Lincolnshire, as well as in the North and South Downs, and in Dorsetshire and the Isle of Wight. Accurate information was obtained by Smith, as we have seen, concerning Scotland and the Isle of Man, which he had never visited, and it may be added, as further evidence of his painstaking inquiries, that a colliery is represented at Bovey Tracey and another in the Eastern Moorlands of Yorkshire.

Alike, then, from its excellence and its defects, this map appeals to British Geologists as being the first sketch—an imperfect one it is true, but far in advance of any earlier or contemporary work—of that remarkable "Map of the Strata of England and Wales" which was published by William Smith in 1815, and which will ever remain the most striking monument of his genius.

III.—On some Rock-Specimens from Kimberley, South Africa.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

A PAPER on the diamantiferous rock of Kimberley by Sir J. B. Stone, M.P., Miss Raisin, and myself, was published in this Magazine in 1895.[1] Since then the first-named has received from friends in South Africa another parcel of specimens, obtained, at a greater depth than heretofore, in the De Beers mine. These specimens, twenty in number, he kindly entrusted to me for description. They represent, as will be seen, not only the diamantiferous breccia, but also the associated igneous and sedimentary rocks. Two specimens among the first-named appeared to be in very good preservation; the others were more or less decomposed, though much more solid than the material which was brought to England in the earlier days of the industry. About the same time I had the opportunity of examining a fine collection of the minerals and rocks which had been obtained by Sir W. Crookes, F.R.S.,[2] during a recent visit to Kimberley. One specimen of diamantiferous breccia among these appeared to me in better preservation than even that which formed the principal subject of our former paper, so he kindly permitted me to have a piece removed for microscopic examination, and a description of it is included in this paper. During the present year the investigations of the Kimberley rock left in manuscript by the late Professor Carvill Lewis have been published,[3] which give a much more elaborate account of its mineral constituents than has hitherto appeared. This enables me to pass rapidly over the mineralogical part of the subject, and to restrict myself to a few details which seem to me of some little petrological interest. The method of working the mines, by sinking vertical shafts outside the area of the "pipe" and driving from them horizontal levels at intervals, is now so well known as to render needless any explanation of the terms employed. I group the specimens, for purposes of description, under three heads: (1) the diamantiferous breccia, (2) the dykes and other igneous rocks, (3) the associated sedimentary rocks.

1. *The Diamantiferous Breccia.*

Of this there are seven specimens, but slices have been cut from three only, for the others, as was proved by a single trial, were not sufficiently well preserved to give useful results. These three proved to be in excellent condition.

Four specimens come from the 1,200-feet level. They are rather irregular in shape, and their volumes probably lie between 15 and 20 cubic inches.[4] They are numbered and labelled as follows:

[1] Geological Magazine, 1895, pp. 492, 496.

[2] Reference to these is made in "The Genesis and Matrix of the Diamond," by the late Professor H. Carvill Lewis, p. 69.

[3] "Papers and Notes on the Genesis and Matrix of the Diamond," 1897 (Longmans).

[4] I mention the size here and elsewhere in order to show that my conclusion as to the origin of the rock is not founded on small specimens, which in the case of so variable a rock as the breccia is of some importance.

"No. 11, Soft Blue, East"; "No. 12, Hard Blue"; "No. 13, West-side Blue"; "No. 14, Soft Blue." All look rather decomposed, No. 13 being, perhaps, in the best condition. The olivine grains are serpentinized or still more decomposed. Brown mica is generally present, but is not abundant; here and there a grain of iron-oxide may be seen, and in one or two a garnet. No. 11 contains several rounded fragments of a compact dull-green rock, with a slight zonal structure near to and symmetrical with the exterior. The largest, which is subangular in shape, measuring about 1″ in length and $\frac{3}{4}$″ in breadth, has been examined microscopically, and will be described later on. No. 12 contains a fair number of small fragments of shale, which have a rather indurated aspect. The block also includes part of a mass of calcite, with a dull-green border. The greatest length of this mass, the exact nature of which I cannot determine, is almost $1\frac{1}{2}$″. No. 13 also contains numerous fragments, very variable in size. Of these a considerable proportion, some angular, some chip-like, represent a blackish shale, the largest specimen being about 1″ in length. In No. 14 small chips of shale are rather numerous.

A slice was cut from (13), since this seemed the more promising of the four specimens, but it could not be made sufficiently thin to give any information of value. The larger olivine grains are evidently much serpentinized. The rock fragments appear to be a hard carbonaceous shale, but to these I shall return.

One specimen, that belonging to Sir W. Crookes, comes from the 1,320-feet level, being marked "No. 22 level, north, Hard-blue." This fragment is slightly pyramidal in shape, the base measuring about $4\frac{1}{2}$″ × $3\frac{1}{2}$″, the greatest height being about 4″. The s.g. is 2·783.[1] The ground-mass is rather compact, in colour blackish-grey, with a purplish tinge. Enclosures are numerous, varying much in size and nature. Of the minerals, olivine is abundant in grains of very variable size, which frequently seem to have escaped serpentinization. Brown mica, garnets, and iron-oxide are also visible, the first being the commonest. Rock fragments are fairly numerous, the most abundant being subangular in outline, dark dull-green in colour, with a lighter border; they are rather serpentinous in aspect, and have a hardness about 3. Some of the smaller are distinctly redder in colour than the rest. Two or three fragments, including the largest (about $\frac{3}{4}$″ × $\frac{3}{8}$″) are more of a grey-green in colour (with a lighter margin), and have a more "speckled" aspect, but they do not materially differ in hardness. Time will be saved by describing together the microscopic structure of this and the next two specimens. These (in Sir J. B. Stone's collection), from the 1,400-feet level, are distinguished on the labels as "15, East Blue" and "16, West Blue."

In (15), a fragment (? with a slight indication of parallel joint planes) approximately 4″ × 3″ × $1\frac{1}{4}$″, the ground-mass resembles that in the specimen last described. Grains and fragments are scattered about it, but rather more sparsely than usual, and they

[1] The specific gravities were determined by a Walker's balance. In this and several other matters I have to thank Miss C. A. Raisin, B.Sc., for kind help.

seldom exceed $\frac{1}{4}''$ in diameter, the largest, a flake of brown mica, being barely $\frac{1}{2}''$. A few of them represent the compact darkish rock with a lighter border, already mentioned; the rest are minerals, most of these being olivine, more or less serpentinized; two or three are brown mica, one or two grains are garnet and iron-oxide—all as usual. The s.g. of the rock is 2·695.

The other fragment (16) is rudely wedge-shaped, the most regular side being about 4″ square. The ground-mass is as above, but the purplish tinge is more variable. Enclosures are fairly numerous, but seldom exceed $\frac{1}{3}''$ in diameter, the largest (olivine, or possibly a peridotite) being about $\frac{1}{2}''$. Olivine, more or less serpentinized, is very abundant in grains markedly variable in size. Other minerals are inconspicuous. There are a few rock fragments, most of them representing the usual compact darkish kind, but the largest one resembles a fine-grained eclogite. The s.g. of the rock is 2·658.

Slices for microscopic examination have been prepared from the specimen from the 1320-feet level and the two from 1400-feet. The first shows a number of fragments, both of mineral and of rock, scattered in a ground-mass; they are more or less rounded, especially the former, which are the more numerous, though here and there the sharp edge of a fracture can be seen. In size they vary from about ·16″ downwards, though larger are present. The minerals are: olivine, enstatite, augite, brown mica, and perofskite. The first and second are partially serpentinized, often only as an external zone, but occasionally to a considerable extent, and a small grain may be entirely changed.[1] In size these olivine grains often vary from about ·0125″ to ·006″, but smaller than the latter may be found, and it is difficult to say where the fragments stop. There are only a few grains of the brownish mica, with the usual external zone. Grains of perofskite are numerous, varying in colour and size; some certainly are of secondary origin, and it is possible that all may be.[2] Small black grains also occur, sometimes associated with these, probably magnetite or ilmenite. The rock fragments, which are very interesting, I leave for the moment. The ground-mass seems to consist of about three minerals, besides grains of opacite and ferrite—(1) a rather flaky mineral, the tints of which, with crossed nicols, do not rise above a dull lead-white; (2) numerous, generally well-defined, flakes, in length up to about ·005″, a very pale-brown tint to colourless, with bright polarization colours—a mica[3]; (3) an irregularly outlined clear granular mineral giving bright tints, probably dolomite.

The specimen from the 1400-feet level labelled "East Blue"

[1] For the structures of the serpentine and the olivine, see Lewis, ut supra, p. 14.

[2] In our former paper we separated the dark-coloured varieties as possibly pseudo-brookite, because we thought sundry slight differences, not only dependent on size, were perceptible. But study of these slices and of Professor Lewis's description makes me doubt whether the latter specimens are more than impure perofskite, so I follow him in placing all under the one name.

[3] A true white mica may be present among them, but in most cases a faint yellowish tint with a trace of pleochroism is perceptible. I think this mineral must be authigenous.

includes mineral and rock fragments, as usual, the largest (rock) being rather more than 3″ in diameter. Among the former, except for one small grain of brown mica, I can only identify with certainty olivine, which shows varying amounts of serpentinization. The matrix differs only in one respect from that last described, and from its usual character in this rock—that it has a more pronounced brown tint, due to the abundance of a rather minute mica, as described above, which sometimes appears almost to form a "setting" for the other minerals. The second specimen, labelled "West Blue," departs in two directions from the normal type: (*a*) the mineral fragments almost all consist of a greenish-yellow serpentine; (*b*) the matrix generally exhibits a distinct warm-brown tint, due to the occurrence of a mica in numerous small rectangular plates. This mica, with a magnification of about 80 linear, is seen to be more definite and regular in outline, richer in colour, and more abundant than in the last-named or in any other specimen that I have examined. In one or two places we find associated with it sporadic clusters of a small prismatic mineral, about ·005″ in length, which is practically colourless, affords high polarization tints, and extinguishes at angles ranging up to about 40°. This mineral, which I think we may identify as an augite, is included in both the mica and the serpentine. The latter mineral, in the matrix or in small enclosures, sometimes exhibits a tendency to spherulitic structure. All, I think, must be of secondary origin, and the aspect of the mica leads me to suspect slight contact metamorphism, such as might be produced by a dyke.

We come next to the rock fragments. A few are holocrystalline; the rest are sedimentary.[1] The former are represented in (*a*) by the following: one which contains parts of two grains of olivine (this, however, might possibly be a compound porphyritic crystal rather than a bit of a peridotite); another which consists of two flakes of brown mica, with an interstitial mineral, probably calcite; a third which is formed of a piece of a garnet, with a border of kelephite (on the outer side only),[2] and of a colourless augite. This, no doubt, represents the rock containing red garnet and green pyroxene[3] which was described from larger fragments by Miss Raisin and myself.[4] Among the fragments more or less certainly of sedimentary origin, the commonest type, subangular in shape, consists of a compact, rather dark-purplish rock, with a pale greenish-grey border, sometimes banded; but the tints exhibit minor variations, small fragments sometimes having their inner part of a paler and redder colour with a more jaspery aspect. The microscopic structure similarly varies. The outer zone commonly exhibits a slight brownish tint, which darkens towards the inner side. With a magnification of about 80 diameters, this is seen to be crowded

[1] For purpose of reference we may denote the specimen from the three places mentioned above as *a*, *b*, *c*, respectively.

[2] This obviously must have been formed after the fragment was imbedded in the breccia.

[3] The chrome diopside of Professor Carvill Lewis, op. cit., p. 21.

[4] Geol. Mag. 1891, p. 412.

with small prisms which give low polarization tints and oblique extinction. These towards the outer part are more thinly scattered, are about five times as long as wide and a little ragged at the ends, and are pale greenish or brownish with rather bright polarization tints and extinction angles high enough for augite. The almost colourless base, in which these and some yet smaller microliths are scattered, seems generally to be isotropic, but here and there small aggregates occur of some feebly double-refracting mineral. The interior of another fragment in (*a*) is more varied: it contains several ragged flakes of a brown mica, somewhat bigger than the prisms. Also minute grains of a clear mineral, with a high refraction index. Their form suggests an isometric mineral, but they afford bright tints with crossed nicols. Thirdly, a fair number of roundish grains of larger size, colourless, but giving faint indications of a flaky structure, with no visible effect on polarized light. The exterior of a fragment in (*b*) shows a considerable amount of a very pale-brown mica, and prisms or flakes of a colourless mineral, extinguishing as hornblende rather than augite. The interior is granular in structure, ferrite-stained, with numerous black specks variable in size and some flakelets of brown mica.[1] It has a fragmental aspect, and may contain some bits of decomposed felspar. In another fragment the narrow outer part is blackened with opacite, though a clear ground-mass, like serpentine, may be distinguished, but the interior is much stained with ferrite. High magnification, however, reveals a fair amount of brown mica and a few black spots (?graphite). The small rock fragments in all the specimens show a general correspondence with the outer zone only of the larger, consisting of flakes or prisms of mica, pyroxene, etc., in a clear ground-mass, resembling a serpentine, but possibly a pseudophite. A subrotund fragment in (11)—the 1200-feet level, East—about 1″ in longer diameter, having the usual purplish-brown interior and a banded greenish-grey outer zone, which is quite $\frac{1}{8}$″ wide, has also been examined. The structure does not essentially differ from some of those described above, except that there is practically no suggestion of contact metamorphism. The interior resembles a mudstone, probably rather carbonaceous, and containing a few flakelets of a colourless mica. The outer zone does not materially differ from the interior, except that it has a rather more clotted aspect, and shows brown lines roughly concentric with the exterior, probably indicating old cracks. In this zone an infiltration of a colourless serpentinous mineral is perceptible, which also occasionally (together with some streaks of a chloritic mineral) fills an interval between the matrix and the fragments, and occupies one or two cracks in the interior.

These specimens of the diamantiferous breccia have afforded me better opportunities of studying included fragments of sedimentary rock than those described in 1895. I believe them to represent ordinary shales or argillites, which have undergone two forms of alteration. The first, not sufficient to change materially the general

[1] Minute perofskite may be present in this fragment.

character of the rock, is probably due to heat; i.e., is a form of contact metamorphism and in most cases is comparatively slight. I have not been able to identify any representatives of a glassy or of a minutely crystalline peridotite, and now, after better opportunities of studying rock fragments than on any former occasion, I feel more doubtful than before whether these really occur. The second alteration—that which has produced the external zoning—I attribute to the action of water, possibly at a fairly high temperature, and probably containing in solution some constituents which it obtained during its passage through the surrounding rock.[1]

The difficulty of ascertaining the true nature of this diamantiferous rock mainly arises from the secondary changes which its matrix has undergone; the principal being infiltration with carbonates and serpentinization. It occurred to me that this might be partially avoided by another method of examination. In the first instance, a small fragment of matrix from Sir W. Crookes' specimen was pulverized, no more force being used than was absolutely necessary. The material, after being kept in H Cl, in one case for perhaps a quarter of an hour, in another for two days (no difference seemed to result), was mounted for microscopic examination. Mineral grains are fairly abundant; mostly olivine, with a very few of augite and mica. Their outlines are distinctly those of fragments, not of crystals. This, of course, might be attributed to the force used in breaking up the rock, but as the matrix is barely half as hard as olivine, and great care was taken, I think it improbable that crystals of this mineral would have been much shattered. However, in order to get rid of this difficulty, some other chips from the same specimen and some bits of ordinary soft blue ground (given to me several years ago by Professor Boyd Dawkins) were immersed in H Cl (50 per cent.). Though the acid was changed and the tubes were frequently shaken, not much powder was detached even at the end of about five months,[2] but the mineral grains in this are identical in shape with those obtained by the other mode of examination. This has materially strengthened my conviction that the "Kimberlite" is in reality a rock of fragmental origin.

(*To be continued.*)

IV.—Sir Henry H. Howorth and the Glaciation of Norway.

By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S.

FEW will deny that whatever comes from the pen of Sir Henry Howorth is always interesting and original, whether the reader agrees with it or otherwise. This is especially the case when he has a theory to build up or to overturn, and in the latter case he not only tries to knock over his antagonist, but he discharges at him

[1] I now think it more likely than when I wrote the preface to Professor Lewis' papers, that this has given a serpentinous aspect to certain small fragments which I then conceived might represent a compact or glassy peridotite.

[2] The pieces left are still too hard to crush between finger and thumb. This seems to indicate that calcite or dolomite is not the only cement of the rock.

volleys of brilliant verbiage with the view to his utter annihilation. On no former occasion has this been exemplified more fully than in his essay on "The Surface Contour of Scandinavia and Finland" in the GEOLOGICAL MAGAZINE for August last, p. 355. In this he has, as he himself says, undertaken "the hazardous work" of overthrowing the Glacial theory as applied to Scandinavia in the face of the evidence which has served to convince the great majority of observers, of the highest eminence and competency, of which amongst those living Professor James Geikie may be considered the chief exponent. In such a case Sir H. Howorth is another *Athanasius contra mundum*. Under the influence of his *perfervidum ingenium* and facile rhetoric the North Sea ice-sheet dissolves, and if it does not become the baseless fabric of a vision, is left as "a very ricketty cripple." Can any state be more deplorable! Glacialists have all been deceived. The North Sea never was packed with ice, stretching to the British shores, and the mammillated rock-surfaces—their parallel grooves and striæ—are deceptions practised by that sad mimic Dame Nature to entrap credulous geologists, who ought to have known that such phenomena are due to "the continued beating, and wearing, and washing of the rocky surfaces of a rising land, assisted possibly in part by shore-ice, and the movement of ice hummocks and gravel, etc."[1] So it all goes for nothing that similarly mammillated and striated surfaces have been observed by numerous naturalists, from Agassiz, Charpentier, and James Forbes downwards, lining the valleys of the Alps, Caucasus, Himalayas, aye, and of Scandinavia itself; for it appears, according to our author, that the inference regarding the mode of formation applied to these is inapplicable in the case of the rocky coasts of Norway. *There* ice has been the sculptor; *here* it has been wave-action and the rest, with "shore-ice" thrown in: but where are we to draw the line?

Such views, coming from so respected a source, filled me with amazement. It required several perusals to make it certain that I myself was not the victim of a hallucination. I had persuaded myself that if any deduction in theoretical geology had been placed upon an unassailable basis it was that of a Scandinavian ice-sheet, which had filled the North Sea and impinged upon our coast. If such were not the case, and the North Sea ice is only a "very ricketty cripple," will Sir H. Howorth explain the remarkable deflection which the glacial *striæ* undergo when traced towards the eastern coast from the interior Highlands and Uplands of Scotland? What other agency than that of *a mer de glace* blocking the seaward path could have caused the old glacier-ice to change its course to the right hand and to the left, and to traverse the Orkneys and Shetlands in a north-westerly direction? Surely not the unresisting waters of an open sea, even if studded with some floating ice! Perhaps this is a problem which may not have presented itself to the mind of the author of the essay; but,

[1] Page 356.

unless he can furnish a sufficient explanation differing from that here suggested, his whole argument falls to the ground.[1]

When we come to inquire what may be the grounds on which Sir H. Howorth has been compelled to dissent from views which have been advanced and illustrated by numerous writers, we find that they are based on the striking evidences of submergence and subsequent emergence which abound around the coasts of Scandinavia and adjoining regions, in which we may include the British Isles; for the Post-Pliocene phenomena of both are similar in kind, if not in degree. These are so obtrusive and overwhelming that they leave no room in the author's mind for the equally striking evidences of extensive glaciation. But the phenomena resulting from both conditions lie side by side; yet are they sufficiently distinct to demand distinct explanation. As regards the proofs of submergence and subsequent elevation we are fully agreed. Some of the evidences adduced by the author, gathered from Credner, regarding the marine forms still surviving in the Swedish, Norwegian, and Finnish lakes, are of extreme interest and importance. These evidences of former Scandinavian submergence to the extent of 600 to 800 feet, based on unquestionable data, are especially opportune, since there are some British geologists who do not admit the evidences of similar subsidence in the case of their own country; but it would have been strange indeed, if not incredible, that Scandinavia could have been depressed to so great an extent while the British Isles remained stationary. Passing, therefore, from the question of subsidence and re-elevation, we have only to deal with that of former elevation and glaciation. On this point, Sir H. Howorth says (p. 360): "They [namely, the champions of the Glacial theory] claim further that before the land was covered by the sea it stood at a probably much higher level than it even does now, and was consequently capable of nursing a great ice-sheet. Of direct evidence of this former higher level of the land, I know none whatever."

In the first place I may observe that direct evidence, such as can be afforded by the glaciated rock-surfaces, can only be followed down to the low-water line, and so far it is clear enough. The polished and striated surfaces may be traced downwards so far; but is there any warrant for supposing that they cease at this line? Nay, is it not more probable that they accompany the surfaces which form the sea-bord down to considerably greater depths? In any case, it is equally open to contend that this is the case, as is the contrary.

But it is here necessary to deny in the most positive terms that the glaciated rock-surfaces which we find lining the coasts and

[1] The course of the ice movement over the same region is shown on Professor James Geikie's glacial map of Scotland, and on one of the general glaciation of the British Isles in the writer's "Physical History of the British Isles" (p. 118, pl. xiii). Also: Croll, "Climate and Time," p. 444; Peach and Horne, Quart. Journ. Geol. Soc., vol. xxxvi, p. 648; T. F. Jamieson, ibid., vol. xxii, p. 261.

islands, scored and grooved in parallel lines over extensive tracts, can be due to wave or current action. Such action would not result in grooving the rocks in rectilinear directions at right angles, or oblique, to the coastline, but sometimes even parallel thereto. As a matter of fact, however, as far as my observation goes (and I have visited a considerable extent of shore-line in all parts of the British Isles and elsewhere) the sea never does sculpture rock-surfaces in the same manner as does glacier-ice, either past or present. Ice-action on rocks is *sui generis*, and sea-action, when opportunity offers, only tends to obliterate, not to produce, the sculptured surfaces.

But notwithstanding our author's statement, there really does exist direct evidence of the former higher level at which the Scandinavian region, including the British Isles, once stood; evidence to which the late Mr. Godwin-Austen was (if I recollect aright) the first to call attention, and which was afterwards more fully worked out by Professor T. Rupert Jones; I refer to the submerged river system of the North Sea plateau. It is well known from soundings that the British Isles and the Scandinavian promontory are planted on a platform of an average depth of 100 fathoms, beyond which the descent is rapid to deeper levels. This platform is known to be traversed by channels continuous with some of the existing larger rivers, which converge towards a main channel, just like tributaries to a large river, and this channel, pursuing a northerly direction, opens out into the Atlantic at the edge of the plateau.[1] There can be no doubt but that these channels were originally those of a river system at a time when the North Sea, or German Ocean, was a land-surface, and stood at least 600 or 700 feet higher than at present, how much higher we cannot tell. But it is worthy of notice, that the extent of the elevation corresponds very closely with that of the depression which may be inferred in the cases of Scandinavia and the British Isles from the levels of shell-bearing beds, amounting altogether to a combined rise and fall of 1,200 to 1,400 feet.

Here, then, is the "direct evidence" of which my distinguished friend stands in need; I do not doubt that he will give it, as also the glacial deflections of Scotland, due consideration.

It now remains to show that the phenomena of submergence and glaciation are not incompatible with each other. The author appears to me to have commenced his historical essay on the Glacial period at Chapter II. The introductory Chapter I, which would deal with elevation and glaciation, he has strangely overlooked. True, that towards the close of this part of his essay he shows by the passage already quoted, that he has had an inkling of an epoch anterior to that of submersion. Let him give the introductory chapter in the history of the Glacial period fair consideration, and then he will see how well it fits in with that epoch to which his mind has been so forcibly directed. It is many years since I held the views for which,

[1] In the paper on "Another possible Cause of the Glacial Epoch," to which the Council of the Geological Society thought proper to refuse publication, I adduced the case of this submerged plateau as being a representative of those of the eastern coast of America and the Antilles so ably worked out by Professor Spencer.

I believe, I am primarily indebted to Lyell; views which I taught to my class in Dublin, and which time has only tended to confirm; namely, that the Great Ice Age was introduced by a general rise of the land bordering the North Atlantic, accompanied by increased cold and Glacial conditions, followed by submergence and inter-Glacial, or milder, conditions of temperature; this again, by emergence and elevation ultimately attaining to the present levels, including minor marginal undulations. These were the three great physical epochs of the Glacial period. When firmly grasped, they are the wards of a key which serves to unlock the many difficulties in the phenomena of the Post-Pliocene period. If Sir Henry Howorth will condescend to make use of this key he will probably find a solution to his difficulties as regards the views of his opponents, while fresh light will be thrown on those he so ably expounds. He will see how it explains the superimposition of marine stratified deposits on glaciated rock-surfaces and *moraine-profonde* matter-deposits, differing in age and in conditions of formation. I am writing these notes at a distance from books, maps, and memoirs, which I hope will be accepted as my apology for errors, whether of omission or commission.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Toronto, August 18th, 1897.

Presidential Address

By Sir John Evans, K.C.B., D.C.L., LL.D., Sc.D., V.P.S.A., For. Sec. G.S., etc.

THE President said the British Association, for a second time, had the honour and pleasure of accepting the hospitality of Canada. On their last visit in 1884, their place of assembly was Montreal, a city which is justly proud of her M'Gill University; to-day they met within the buildings of another of the Universities of the vast Dominion, and in a city the absolute fitness of which for such a purpose must have been foreseen by the native Indian tribes when they gave to a small aggregation of huts upon that spot the name of Toronto—"the place of meetings." His election to the important post he now held might, in the main, be regarded as a recognition by this Association of the value of Archæology as a science. It was no doubt hard to define the exact limits to be assigned to Archæology as a science, and Archæology as a branch of history and *belles lettres*. A distinction did, however, exist between Archæology proper and what, for want of a better word, might be termed Antiquarianism.

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A familiarity with all the details of Greek and Roman mythology and culture must be regarded as a literary rather than a scientific qualification; and yet, when among the records of classical times they came upon traces of manners and customs which had survived for generations, and which seemed to throw some rays of light upon

the dim past, when history and writing were unknown, they were approaching the boundaries of scientific Archæology.

Every reader of Virgil knew that the Greeks were not merely orators, but that with a pair of compasses they could describe the movements of the heavens and fix the rising of the stars; but when by modern Astronomy we could determine the heliacal rising of some well-known star, with which the worship in some given ancient temple was known to have been connected, and could fix its position on the horizon at some particular spot, say, three thousand years ago, and then found that the axis of the temple was directed exactly towards that spot, we had some trustworthy scientific evidence that the temple in question must have been erected at a date approximately 1100 years B.C. If on or close to the same site we found that more than one temple was erected, each having a different orientation, these variations, following as they might fairly be presumed to do, the changing position of the rising of the dominant star, would also afford a guide as to the chronological order of the different foundations. The researches of Mr. Penrose seemed to show that in certain Greek temples, of which the date of foundation was known from history, the actual orientation corresponded with that theoretically deduced from astronomical data.

Sir J. Norman Lockyer had shown that what holds good for Greek temples applied to many of far earlier date in Egypt, though up to the present time hardly a sufficient number of accurate observations had been made to justify us in foreseeing all the instructive results that might be expected to arise from Astronomy coming to the aid of Archæology.

The intimate connection of Archæology with other sciences was in no case so evident as with respect to Geology.

By the application of geological methods many archæological questions relating even to subjects on the borders of the historical period had been satisfactorily solved.

When they came to the consideration of the relics of the Early Iron and Bronze Ages, the aid of chemistry had of necessity to be invoked. By its means they were able to determine whether the iron of a tool or weapon was of meteoritic or volcanic origin, or had been reduced from iron-ore, in which case considerable knowledge of metallurgy would be involved on the part of those who made it. With bronze antiquities the nature and extent of the alloys combined with the copper might throw light not only on their chronological position, but on the sources whence the copper, tin, and other metals of which they consisted were originally derived.

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Like Chemistry, Mineralogy and Petrology might be called to the assistance of Archæology in determining the nature and source of the rocks of which ancient stone implements were made; and, thanks to researches of the followers of those sciences, the old view that all such implements formed of jade and found in Europe must

of necessity have been fashioned from material imported from Asia could no longer be maintained. In one respect the Archæologist differed in opinion from the Mineralogist, namely, as to the propriety of chipping off fragments from perfect and highly-finished specimens for the purpose of submitting them to microscopic examination.

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When they came to discuss that remote age in which were found the earliest traces at present known of man's appearance upon earth, the aid of Geology and Palæontology became absolutely imperative.

The changes in the surface configuration and in the extent of the land, especially in a country like Britain, as well as the modifications of the fauna and flora since those days, had been such that the archæologist pure and simple was incompetent to deal with them, and he must either himself undertake the study of these other sciences or call experts in them to his assistance. The evidence that man had already appeared upon the earth was afforded by stone implements wrought by his hands, and it fell strictly within the province of the archæologist to judge whether given specimens were so wrought or not; it rested with the geologist to determine their stratigraphical or chronological position, while the palæontologist could pronounce upon the age and character of the associated fauna and flora.

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Of late years the general tendency of those engaged upon the question of the antiquity of the human race had been in the direction of seeking for evidence by which the existence of Man upon the earth could be carried back to a date earlier than that of the Quaternary gravels.

There is little doubt that such evidence would eventually be forthcoming, but, judging from all probability, it was not in Northern Europe that the cradle of the human race would eventually be discovered, but in some part of the world more favoured by a tropical climate, where abundant means of subsistence could be procured, and where the necessity for warm clothing did not exist.

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With Palæolithic man, we were treading on comparatively secure ground, and the discoveries of the last forty years in Britain alone enabled us to a great extent to reconstitute his history. We might not know the exact geological period when first he settled in the British area, but we had good evidence that he occupied it at a time when the configuration of the surface was entirely different from what it is at present; when the river valleys had not been cut down to anything like their existing depth, when the fauna of the country was of a totally different character from that of the present day, when the extension of the southern part of the island seaward was in places such that the land was continuous with that of the continent, and when in all probability a far

more rainy climate prevailed. We had proofs of the occupation of the country by man during the long lapse of time that was necessary for the excavation of the river valleys. We had found the old floors on which his habitations were fixed, we had been able to trace him at work on the manufacture of flint instruments, and by building up, the one upon the other, the flakes struck off by the primæval workmen in those remote times we had been able to reconstruct the blocks of flint which served as his material.

That the duration of the Palæolithic Period must have extended over an almost incredible length of time, was sufficiently proved by the fact that valleys, some miles in width and of a depth of from 100 to 150 feet, had been eroded since the deposit of the earliest implement-bearing beds. Nor was the apparent duration of this period diminished by the consideration that the floods which hollowed out the valleys were not in all probability of such frequent occurrence as to teach Palæolithic man by experience the danger of settling so near to the streams, for had he kept to the higher slopes of the valley there would have been but little chance of his implements having so constantly formed constituent parts of the gravels deposited by the floods.

The examination of British cave-deposits as at Kent's Cavern, Torquay, afforded corroborative evidence of this extended duration of the Palæolithic Period.

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In a cavern at Creswell Crags, on the confines of Derbyshire and Nottinghamshire, a bone had been found engraved with a representation of parts of a horse in precisely the same style as the engraved bones of the French caves.

It was uncertain whether any of the river-drift specimens belonged to so late a date as these artistic cavern-remains; but the greatly superior antiquity of even these to any Neolithic relics was testified by the thick layer of stalagmite, which had been deposited in Kent's Cavern before its occupation by men of the Neolithic and Bronze Periods.

Towards the close of the period covered by the human occupation of the French caves, there seemed to have been a dwindling in the number of the larger animals constituting the Quaternary fauna, whereas their remains were present in abundance in the lower and therefore more recent of the valley gravels. This circumstance might afford an argument in favour of regarding the period represented by the later French caves as a continuation of that during which the old river gravels were deposited; and yet the great change in the fauna that had taken place since the latest of the cave-deposits included in the Palæolithic Period was indicative of an immense lapse of time.

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We found distinct traces of river-action from 100 to 200 feet above the level of existing streams and rivers, and sometimes at a great distance from them; we observed old fresh-water deposits on the slopes of valleys several miles in width; we found that

long and lofty escarpments of rock had receded unknown distances since their summits were first occupied by Palæolithic man; we saw that the whole side of a wide river valley had been carried away by an invasion of the sea, which attacked and removed a barrier of chalk cliffs from 400 to 600 feet in height; we found what was formerly an inland river had been widened out into an arm of the sea, now the highway of our fleets, and that gravels which were originally deposited in the bed of some ancient river now capped isolated and lofty hills.

And yet, remote as the date of the first known occupation of Britain by man might be, it belonged to what, geologically speaking, must be regarded as a quite recent period, for we were now in a position to fix with some degree of accuracy its place on the geological scale. Thanks to the investigations ably carried out at Hoxne in Suffolk, and at Hitchin in Hertfordshire, by Mr. Clement Reid, under the auspices of that Association and of the Royal Society, we knew that the implement-bearing beds at those places undoubtedly belonged to a time subsequent to the deposit of the Great Chalky Boulder-clay of the Eastern counties of England. It was, of course, self-evident that this vast deposit, in whatever manner it might have been formed, could not, for centuries after its deposition was complete, have presented a surface inhabitable by man. Moreover, at a distance but little farther north, beds existed which also, though at a somewhat later date, were apparently formed under glacial conditions. At Hoxne the interval between the deposit of the Boulder-clay and of the implement-bearing beds was distinctly proved to have witnessed at least two noteworthy changes in climate. The beds immediately reposing on the clay were characterized by the presence of alder in abundance, of hazel, and yew, as well as by that of numerous flowering plants indicative of a temperate climate very different from that under which the Boulder-clay itself was formed. Above these beds, characterized by temperate plants, came a thick and more recent series of strata, in which leaves of the dwarf Arctic willow and birch abounded, and which were in all probability deposited under conditions like those of the cold regions of Siberia and North America.

At a higher level, and of more recent date than these—from which they were entirely distinct—were the beds containing Palæolithic implements, formed in all probability under conditions not essentially different from those of the present day. However this might be, we had now conclusive evidence that the Palæolithic implements were, in the Eastern counties of England, of a date long posterior to that of the Great Chalky Boulder-clay.

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It must not, however, for a moment be supposed that there were the slightest grounds for believing that the civilization, such as it was, of the Palæolithic period originated in the British Isles. We found in other countries implements so identical in form and character with British specimens that they might have been

manufactured by the same hands. These occurred over large areas in France under similar conditions to those that prevailed in England. The same forms had been discovered in the ancient river gravels of Italy, Spain, and Portugal. Some few had been recorded from the North of Africa, and analogous types occurred in considerable numbers in the south of that continent. On the banks of the Nile, many hundreds of feet above its present level, implements of the European types had been discovered; while in Somali-land, in an ancient river valley at a great elevation above the sea, Mr. Seton-Karr had collected a large number of implements formed of flint and quartzite, which, judging from their form and character, might have been dug out of the drift deposits of the Somme or the Seine, the Thames or the ancient Solent.

In the valley of the Euphrates implements of the same kind had also been found, and again farther east in the Lateritic deposits of Southern India they have been obtained in considerable numbers.

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Was this not a case in which the imagination might be fairly invoked in aid of science? Might we not from these data attempt in some degree to build up and reconstruct the early history of the human family? There, in Eastern Asia, in a tropical climate, with the means of subsistence readily at hand, might we not picture to ourselves our earliest ancestors gradually developing from a lowly origin, acquiring a taste for hunting, if not indeed being driven to protect themselves from the beasts around them, and evolving the more complicated forms of tools or weapons from the simpler flakes which had previously served them as knives? Might we not imagine that, when once the stage of civilization denoted by these Palæolithic implements had been reached, the game for the hunter became scarcer, and that his life in consequence assumed a more nomad character? Then, and possibly not till then, might a series of migrations to "fresh woods and pastures new" not unnaturally have ensued, and these following the usual course of "westward towards the setting sun" might eventually lead to a Palæolithic population finding its way to the extreme borders of Western Europe, where we found such numerous traces of its presence.

How long a term of years might be involved in such a migration it was impossible to say, but that such a migration took place the phenomena seemed to justify us in believing.

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As yet, our records of discoveries in India and Eastern Asia were but scanty; but it was there that the traces of the cradle of the human race were, in his opinion, to be sought, and possibly future discoveries might place upon a more solid foundation the visionary structure he had ventured to erect.

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It might be worth while to carry their speculations rather further, and to consider the relations in time between the Palæolithic and the Neolithic Periods.

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At the close of the period during which the valleys were being eroded came that represented by the latest occupation of the caves by Palæolithic man, when, both in Britain and in the south of France, the reindeer was abundant; but, among the stone weapons and implements of that long troglodytic phase of man's history, not a single example with the edge sharpened by grinding had as yet been found. All that could safely be said was that the larger implements, as well as the larger mammals, had become scarcer, that greater power in chipping flint had been attained, that the arts of the engraver and the sculptor had considerably developed, and that the use of the bow had probably been discovered.

Directly they encountered the relics of the Neolithic Period, often, in the case of the caves lately mentioned, separated from the earlier remains by a thick layer of underlying stalagmite, they found flint hatchets polished at the edge and on the surface, cutting at the broad and not at the narrow end, and other forms of implements associated with a fauna in all essential respects identical with that of the present day.

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So far as he knew we had as yet no trustworthy evidence of any transition from the one age to the other, and the gulf between them remained practically unbridged. We could, indeed, hardly name the part of the world in which to seek the cradle of Neolithic civilization, though we know that traces of what appeared to have been a stone-using people had been discovered in Egypt, and that what must be among the latest of the relics of their industry had been assigned to a date some 3,500 to 4,000 years before our era. The men of that time had attained to the highest degree of skill in working flint that had ever been reached. Their beautifully-made knives and spear-heads seemed indicative of a culminating point reached after long ages of experience; but whence these artists in flint came or who they were was at present absolutely unknown, and their handiworks afforded no clue to help us in tracing their origin.

Taking a wider survey, we might say that, generally speaking, not only the fauna but the surface configuration of the country were, in Western Europe at all events, much the same at the commencement of the Neolithic Period as they are at the present day. We had, too, no geological indications to aid us in forming any chronological scale.

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But, pending the advent of evidence to the contrary, we might provisionally adopt the view that owing to failure of food, climatal changes, or other causes, the occupation of Western Europe by Palæolithic man absolutely ceased, and that it was not until after an interval of long duration that Europe was repeopled by a race of men immigrating from some other part of the globe where the human race had survived, and in course of ages had developed a higher stage of culture than that of the Palæolithic man.

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Returning to the realms of fact, one fact on which he desired to insist was that of the existence at the present day, in close juxtaposition with our own civilization, of races of men who, at all events but a few generations ago, lived under much the same conditions as did our own Neolithic predecessors in Europe.

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The manners and customs of these primitive tribes and peoples were changing day by day, their languages were becoming obsolete, their myths and traditions were dying out, their ancient processes of manufacture were falling into oblivion, and their numbers were rapidly diminishing, so that it seemed inevitable that ere long many of these interesting populations would become absolutely extinct. The admirable Bureau of Ethnology instituted in the United States of America had done much towards preserving a knowledge of the various native races on that vast Continent; and in Canada the annual Archæological Reports presented to the Minister of Education were rendering good service in the same cause.

Moreover, the Committee of the British Association appointed to investigate the physical characters, languages, and industrial and social conditions of the North-Western tribes of the Dominion of Canada was about to present its twelfth and final report, which, in conjunction with those already presented, would do much towards preserving a knowledge of the habits and languages of those tribes.

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It was, however, lamentable to notice how little was being or had been officially done towards preserving a full record of the habits, beliefs, arts, myths, languages, and physical characteristics of the countless other tribes and nations, more or less uncivilized, which were comprised within the limits of the British Empire. At the meeting of this Association held last year in Liverpool it was resolved by the General Committee to press upon the Government the necessity of establishing a Bureau of Ethnology for Greater Britain. Wherever such a bureau was to be established, in connection with the British Museum or the Imperial Institute . . . . the question of its existence must of necessity rest with Her Majesty's Government and Treasury, inasmuch as without funds, however moderate, the undertaking could not be carried on. He trusted that, in considering the question, it would always be borne in mind that in the relations between civilized and uncivilized nations and races it was of the first importance that the prejudices, and especially the religious or semi-religious and caste prejudices, of the latter should be thoroughly well known to the former. If but a single "little war" could be avoided in consequence of the knowledge acquired and stored up by the Bureau of Ethnology preventing such a misunderstanding as might culminate in warfare, the cost of such an institution would quickly be saved.

It might be thought that he should have taken that opportunity to discuss some more general subject, such as the advances made in the various departments of science since last the Association met in Canada. These topics would, however, be discussed by more competent

authorities in the various Sections of the Association by means of the Presidential addresses or otherwise. He occupied his position as a representative of Archæology, and was, therefore, justified in bringing before them a subject in which every member of every race of mankind ought to be interested—the antiquity of the human family and the scenes of its infancy.

Others would direct their thoughts in other directions, but the farther they proceeded the more clearly would they realize the connection and interdependence of all departments of science. Year after year, as meetings of this Association took place, they might foresee that "many shall run to and fro and knowledge shall be increased." Year after year advances would be made in science; and in reading that Book of Nature which was ever open before their eyes, successive stones would be brought for building up that Temple of Knowledge of which their fathers and they had laboured to lay the foundations.

II.—British Association for the Advancement of Science. Sixty-Seventh Annual Meeting, held at Toronto, Canada, August 18–25, 1897.

List of Papers read in Section C, Geology.

Dr. G. M. Dawson, C.M.G., F.R.S., F.G.S., President.

President's Address.—On the Pre-Cambrian Rocks of Canada.

Dr. F. D. Adams.—On the Structure and Origin of certain Rocks of the Laurentian System.

Dr. R. W. Ells.—Problems in Quebec Geology.

Dr. L. W. Bailey.—Some Typical Sections in South-Western Nova Scotia.

Dr. E. W. Claypole.—Palæozoic Geography of the Eastern States.

J. C. Branner.—The Former Extension of the Appalachians across Mississippi, Louisiana, and Texas.

Dr. F. D. Adams and *J. T. Nicholson.*—Preliminary Notice of some Experiments on the Flow of Rocks.

Professor W. J. Sollas, F.R.S.—Report of the Committee for the Investigation of a Coral Reef.

E. J. Garwood.—Report of the Committee on Life-Zones in the British Carboniferous Rocks.

R. T. Hill.—The Stratigraphic Succession in Jamaica.

Professor T. C. Chamberlin.—A Group of Hypotheses bearing on Climatic Changes.

Professor T. C. Chamberlin.—Distribution and Succession of the Pleistocene Ice-Sheets of the Northern United States.

Professor A. Penck.—The Glacial Deposits of the Alps.

Prince Kropotkin.—On the Asar of Finland.

H. B. Woodward, F.R.S.—The Chalky Boulder-Clay and the Glacial Phenomena of the Western-Midland Counties of England.

Professor A. P. Coleman.—Glacial and Interglacial Deposits at Toronto.

Dr. J. W Spencer.—On the Continental Elevation of the Glacial Epoch.

F. B. Taylor.—The Champlain Submergence and Uplift, and their Relations to the Great Lakes and Niagara Falls.

G. K. Gilbert.—Remarks introductory to the Excursion to Niagara Falls and Gorge.

Bailey Willis.—Drift Phenomena of Puget Sound and their Interpretation.

Professor C. H. Hitchcock.—The Southern Lobe of the Laurentian Ice-Sheet.

Professor N. S. Shaler.—On the Origin of Drumlins.

R. Chalmers.—The Pre-Glacial Decay of Rocks in Eastern Canada.

Sir William Dawson, F.R.S.—Note on certain Pre-Cambrian and Cambrian Fossils supposed to be related to Eozoon.

A. C. Seward, M.A. — On the Possible Identity of *Bennettites, Williamsonia*, and *Zamites gigas*.

J. F. Whiteaves.—Note on a Dendrodont Fish-tooth from Silurian Rocks of Nova Scotia.

H. M. Ami, D.Sc.—On some new or hitherto little known Palæozoic Formations in North-Eastern America.

Dr. G. F. Matthew.—Some Characteristic Genera of the Cambrian.

Professor T. Rupert Jones, F.R.S.—Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks.

J. Milne and *A. J. Jukes-Browne.*—Report of the Committee on the Secondary Fossils of Moreseat, Aberdeenshire.

M. l'Abbé J. C K. Laflamme.—Influence d'un éboulement sur le régime d'une Rivière.

Captain S. G. McDakin.—Report of the Coast Erosion Committee of the East Kent and Dover Natural History Societies.

H. N. Ridley.—Report of the Committee on the Fauna of Caves near Singapore.

P. F. Kendall.—Report of the Committee on the Erratic Blocks of the British Islands.

A. E. Barlow, M.A., and *W. F. Ferrier, B.Sc.* — On the Relations and Structure of certain Granites and associated Arkoses on Lake Temiscaming, Canada.

P. M. C. Kermode.—Report of the Committee on the Irish Elk Remains in the Isle of Man.

Professor W. G. Miller.—On some Nickeliferous Magnetites.

J. J. H. Teall, F.R.S.—Differentiation in Igneous Magmas as a result of Progressive Crystallization.

J. B. Tyrrell, B.Sc.—The Glaciation of North-Central Canada.

Dr. E. Gilpin, Jun.—The Geological Horizon of some Nova Scotia Minerals.

W. F. Ferrier, B.Sc.—The Minerals of the Elæolite-syenite near Montreal.

W. L. Goodwin and *Professor W. G. Miller.* — Some Economic Minerals of Ontario.

Professor H. Le Roy Fairchild.—Glacial Geology of Western New York.

Professor J. Milne, F.R.S.—Second Report on Seismological Investigation.
O. H. Howarth.—Earth Strains and Structure.
Professor W. W. Watts.—Report of the Committee for Collecting Photographs of Geological Interest.
Dr. Otto Hahn.—Exhibit of Photographs and Sections of Meteorites.

Papers bearing upon Geology and Palæontology read in other Sections, namely :

Section A.—Mathematical and Physical Science.

Lord Kelvin.—On the Fuel-Supply and Air-Supply of the World.

Section B.—Chemistry.

F. T. Shutt.—The Composition of Canadian Virgin Soils.
Professor W. H. Ellis.—Analyses of some Pre-Carboniferous Coals.
Report of the Committee to inquire into the Proximate Chemical Constituents of the various kinds of Coal.

Section D.—Zoology.

Professor H. F. Osborn.—On a Restoration of *Phenacodus primævus*.
Professor H. F. Osborn.—On Skeletons and Restorations of Tertiary Mammalia.
J. F. Whiteaves.—On new Sepiadæ from the Lower Cretaceous of the South Saskatchewan.
Professor C. S. Minot.—The Origin of Vertebrata.
Professor H. F. Osborn.—The Origin of Mammalia.

Section E.—Geography.

J. B. Tyrrell.—The Barren Lands of Canada.
Charles D. Walcott.—The Geographical Work of the United States Geological Survey.
J. White.—The Geographical Work of the Canadian Geological Survey.

Section H.—Anthropology.

Joint Discussion with Section C, Geology.—*Subject* : "The First Traces of Man in the New World."

Professor F. W. Putnam.—The Trenton Gravels.
Professor E. W. Claypole.—Human Relics in the Drift of Ohio.
The President.—Exhibition of Lance-headed Implements of Glass from North-West Australia.
F. H. Cushing.—The Genesis of Implement-Making.
Professor A. C. Haddon.—Adze-Making in the Andaman Islands.

Section K.—Botany.

A. C. Seward.—Lecture on Fossil Plants.
A. C. Seward.—Notes on Fossil Equisetaceæ.

REVIEWS.

I.—On the Origin of the European Fauna. By R. F. Scharff, Ph.D., B.Sc., F.Z.S., Keeper of the Natural History Collections in the Dublin Museum of Science and Art. Proc. Roy. Irish Acad., 3rd ser., vol. iv, No. 3, 1897, pp. 427–514. 8vo. (Dublin, 1897.)

(*Continued from the September Number, page* 427.)

PURSUING his inquiry into the origin of the European Fauna, Dr. Scharff advocates, with the Russian Naturalist Tcherski, a mild climate in Pleistocene times for Northern Asia.

The Climate of Siberia and Northern Russia during the Glacial Period.—"We have to choose between one of two alternatives—either Northern Russia was covered by a mass of ice, and then Siberia must have been practically uninhabitable, or the climate of both Europe and Siberia were more temperate than it is now. In the face of the numerous works which have been written in recent years by Professor J. Geikie, Professor Penck, Mr. Falsan, Professor Bonney, and many other distinguished geologists, on the proofs of a cold and even Arctic climate in Europe during the Glacial period, it may seem futile to doubt what is put forward as a well-established fact. But with Tcherski I have been led to conclude that Siberia had a comparatively mild climate in Pleistocene times. Northern Europe could not, that being the case, have been glaciated in the manner above described. Before following the migrations of the Siberian fauna to Europe, I must therefore dwell for a little while on the origin of the Continental Boulder-clay." (p. 457.)

Origin of the Boulder-clay.—"I think that I shall be able to advance some additional evidence in favour of the view that the Boulder-clay of Europe is a marine deposit, and that Northern Russia and Germany were not covered by glaciers during the Pliocene or Pleistocene epochs.

"It has been urged by many writers, both on zoological and geological grounds, that at some time during the Pleistocene epoch, or perhaps even later, the White Sea and the Baltic were joined across Northern Russia, and that then also the lowlands of Northern Germany and those of Sweden and Norway were partially flooded. The zoological evidence alone, that such a junction has taken place within recent geological times, is very strong indeed." (p. 458.)

"The assumption that the Arctic mollusca were admitted from the Atlantic to the German Ocean before the deposition of the Lower Boulder-clay, and then found their way into the Baltic, is altogether unwarranted. It is extremely probable that Scotland was connected with Scandinavia till a much more recent period. It is likely, therefore, that a marine transgression from the White Sea took place at the time when the Aralo-Caspian extended much further north than its present boundaries, that the Arctic mollusca migrated from the Arctic Ocean direct to the Baltic, where the Pre-Glacial deposits exhibit a curious intermingling of

the ancient southern fauna with the newer immigrants from the north.

"Deposits containing Arctic marine mollusca were also discovered below the Boulder-clay near the shores of the White Sea, another proof of the former extension of the Arctic Ocean in this direction."

Former Land-connection between Scandinavia and North Greenland.—"I can only allude at present to an important feature in the physical geography of Northern Europe, viz., the former continuation of the Scandinavian coastline in a north-westerly direction to Spitzbergen and North Greenland. The cold waters of the Arctic Ocean did not communicate at all with the Atlantic at the time when the above-mentioned changes occurred in Northern Europe, but they poured into the Baltic and the German Ocean, which was then a closed bay, and brought with them the characteristic fauna of the Arctic regions."

The Lowlands of Northern Europe covered by the Sea.—"The Aralo-Caspian communicated with this large northern sea, which had formed on the North European lowlands, and which we may call the "North European Ocean," at a time immediately preceding the deposition of the Upper Boulder-clay. But the barrier which prevented the Siberian fauna from entering Europe was the strait or straits which connected the two seas. We can, therefore, accurately fix the period of the beginning of the migration, for it must have occurred as soon as this barrier disappeared; or, if we are able to ascertain stratigraphically the first appearance of the Siberian immigrants in Central Europe, the disappearance of the barrier must have immediately preceded that period." (p. 462.)

Remains of Siberian Fauna found fossil in England.—"We know that in England remains of Siberian mammals occur from the Forest-bed upward, whilst none are found in older strata. It seems safe to conclude, therefore, that the Siberian migration took place after the deposition of the Lower Continental Boulder-clay, and during or just previous to the formation of the Forest-bed. But the latter has been lately recognized as a Pre-Glacial formation, and it certainly underlies the English Boulder-clay. How can we then reconcile these two apparently very contradictory conclusions—that a migration which undoubtedly set out from the East arrived in Western Europe before it reached Central Europe?

"I have shown in a previous paper that such was certainly the case with some southern Asiatic mammals, which entered Europe from Greece, and migrated along the Mediterranean coast to Northern Africa at a time when a land-bridge still existed between it and Southern Italy, and then recrossed again to Spain, where at last they turned north to appear in Western Europe, without having crossed the central parts of the continent. Such, however, could not possibly have been the course of migration of the Siberian mammals, since they are not found in Southern Europe or in North Africa. Hence one of the two alternatives must be accepted: either some radical mistake has been made in the previous arguments, or the Forest-bed is an Interglacial deposit, and contemporaneous with

the 'Loess' formation in which the Siberian animals have been discovered in Northern Germany. I believe in the latter hypothesis. If this view should be correct, the whole of the British Pliocene strata, or a portion of them, must be of the same age as the Lower Continental Boulder-clay. The marine fauna which made its way west from the Arctic Ocean across the North Russian plains, and reappeared again on the Baltic coasts just before the deposition of the Boulder-clay, must have entered the German Ocean and left its traces behind in the strata which formed on the east coast of England. And this is precisely what occurred. 'In the oldest member of the Pliocene system,' remarks Professor J. Geikie 'in the Coralline Crag, the general facies of the fauna clearly indicates a warm, temperate climate, for all the living species are southern forms. In the Red Crag, however, northern forms begin to appear, and increase in numbers as we pass upwards to the higher members, while at the same time the extinct and southern forms gradually die out.' If the view that the Forest-bed represents an Interglacial deposit is correct, as indeed has already been suggested by Professor Geikie, the whole of the newer British Pliocene is synchronous with the Lower Continental Boulder-clay." (p. 463.)

On the Condition of the Old Land-surface in Southern Russia during the Siberian Migration to the West.—"We may assume, therefore, that this tract of land, over which the Siberian fauna wandered, consisted of a vast prairie. On their arrival in the more central parts of Europe, the Siberian mammals spread into Austria, Hungary, and Northern Italy, throughout the greater part of Germany and France, and into England. They scarcely touched any part of Southern Europe, and their progress in France was apparently arrested by the Garonne, as no typical Siberian forms are found fossil south of that river, in the Pyrenees, or in Spain. Of course, more recently the Siberian survivors in Europe have spread not only into Southern Italy and Spain, but also throughout Great Britain and Scandinavia. But none of them entered Ireland, and I have given this as one of my reasons for the belief that this country became separated from England about the time when the Forest-bed was laid down, and has never since been joined to it.

"It is evident that during the deposition of the Forest-bed, the South of England was joined to France. But the two countries must have been united for a considerable time previously, and this is quite in accordance with the opinion expressed by geologists."

The Scandinavian Peninsula.—"As regards the Scandinavian Peninsula, the total absence of mammalian remains in Pleistocene deposits indicates that this country was not connected with the Continent during that period. The presence, on the other hand, of mammalian remains in more recent deposits, chiefly in Southern Sweden, implies that towards the end of the Glacial period, a land-passage must have existed between North-Western Germany and Sweden across Denmark. In referring to the absence of fossil elephants

and other large mammals from the Scandinavian Pleistocene strata, Professor Pohlig expresses the belief that Scandinavia must either have been hardly free from ice during the whole of the Glacial period, or, if free from ice during Interglacial times, it could then only have had an imperfect connection with the Continent. That of these alternatives the former was not the case, and if, as I believe, the bulk of the fauna and flora survived the Glacial period in the country itself from Pre-Glacial times, there is no necessity for supposing that any connection existed between the Continent and Scandinavia in Interglacial times." (p. 468.)

The Arctic Migration.—"Three of the Irish mammals, one of which, the reindeer, is now extinct, appear to me to have come direct from the north. Several birds, among the most striking of which may be mentioned the grouse (*Lagopus scoticus*) have formed part of that northern migration. All the Salmonidæ have come to us from the north, whilst a still more noteworthy example of a northern migrant is the stickleback (*Gasterosteus aculeatus*). The land-shells *Helix lamellata* and *Vertigo alpestris*, the beetles *Pelophila borealis*, *Dytiscus lapponicus*, *Blethisa multipunctata*, and the moth *Crymodes exulis*, all belong to the same migration. No doubt these and the North American fresh-water sponges, which have been recently discovered on the west coast by the Royal Irish Academy Fauna and Flora Committee, have found their way to Ireland along an old land-connection which formerly united that country with the Arctic regions. In the latter may have originated many of these forms, as well as the plants already referred to, and have migrated to both the Old and the New World. Of course, I have selected only a few of the more prominent examples. As our knowledge of the geographical distribution of the species, which is as yet in its infancy, increases, many other of these northern forms will no doubt be discovered in Ireland."

Arctic Species in Scotland.—"If we cross over to Scotland, we find a very large increase of typically Arctic species of animals and plants; and as these are absent from England, or confined to the Northern counties, there can be no question as to their having migrated direct from the north to Scotland by a former land-passage. It may be urged that these Arctic species have spread over the plain of Europe, have then entered England from the south, and have subsequently been exterminated except in their most northern stations in the British Islands. But whilst we have only very slender geological evidence that such might have been the case; there is, I think, strong evidence for the belief that, until comparatively recent times, Norway and Scotland were joined, so that animals and plants had no need to migrate by that enormously circuitous route by way of Denmark, Holland, Belgium, and England, and across the many large rivers which would have impeded their journey. In Scandinavia, Arctic animals and plants form a large proportion of the fauna and flora, and as we proceed northward, southern forms become more and more scarce. According to Mr. Peterson, no less than thirteen species of Arctic Lepidoptera

occur in Northern Europe and North America, but are absent from Asia, and he assumes the probability of a direct land-connection between the two countries by way of Greenland before the Glacial period, and a survival of these in Europe."

Former Land-connection between Greenland, Scandinavia, and the British Islands.—"I think it has been clearly shown that a former land-connection must have existed between Scandinavia and Greenland on the one hand, and between Scandinavia and the British Islands on the other, and that it formed the highway for an extensive migration from the north, and *vice versâ*. Most naturalists, indeed, admit this, but many deny that it could have been anything but Post-Glacial. I believe that the migration took place chiefly in later Pliocene times, i.e. during the deposition of the newer Crags and of the Lower Continental Boulder-clay. The Arctic animals and plants certainly reached the British Islands long before the Siberian immigrants. Throughout the Glacial period (inclusive of the period when the newer Crags were deposited) the White Sea remained connected with the Baltic and the German Ocean, forming the great sea which I ventured to call the North European Sea. Long before the Arctic migration reached the British Islands, another migration advanced from the south; first, as I explained, from South-Western Europe, and, as the climate became colder, from Southern and Central Europe. Many of the animals and plants which arrived with the latter straggled northward into Scandinavia, and even at the present moment they seek to extend their range in a northerly direction. There is no evidence that their progress was checked by the Arctic climate, which is supposed to have prevailed during the Glacial period." (p. 479.)

The Southern Migration.—"The bulk of the Irish fauna and flora belongs to the Southern Migration, and we can divide its members again roughly into those of South-Western and those of Southern or Central European origin. But, in reality, the origin of this migration is an exceedingly complex one, and is all the more difficult to trace as migrations from the south to the north have apparently proceeded uninterruptedly during many of the past geological epochs—certainly during the whole of the Tertiary era. Whilst most of the larger and short-lived forms have died out again, some of the less conspicuous invertebrates are undoubtedly of very ancient origin, and have witnessed vast changes in the fauna and flora surrounding them. Many of these, though their general distribution indicates a southern origin, baffle all attempts at solving the problem of the location of their ancestral home. In some respects the southern migration merges into the Siberian one; for there are a good many English species of animals and plants which, though absent from Ireland, belong certainly to the former. The dormouse (*Muscardinus avellanarius*), for instance, is probably of Central European origin, but it nevertheless is absent from Ireland.[1] Its general range, however, proves that it is of very

[1] See on this point our criticism in the September number of the GEOL. MAG. on p. 421.

recent origin, and it has only spread from its original home, which may be in the Alps, after Ireland was already disconnected from Great Britain. It has never reached Scotland, Spain, Norway, Russia, Greece, or any of the Mediterranean islands, except Sicily, where it is present, according to Döederlein. Then there are forms which, though they have come to the British Islands from Southern Europe, have probably not originated there, but in Central or Southern Asia. Certain of these Asiatic species have joined what I call this 'Southern Migration,' but subsequently they have invaded Europe along with the Siberian Migration. In most of these instances, however, the members of the earlier Southern Migration belong to a different variety from those of the later ones, or exhibit such racial characters, that naturalists are able to distinguish them from one another, and thus differentiate between the two migrations" (p. 480). The author cites two such cases, namely, those of the European hare and the bullfinch.

Insular Mollusca.—"The mollusca of islands are of great importance in studying geographical distribution. A knowledge of the mollusca of such islands as Ireland, Sardinia, and Corsica, will help us to solve many of the problems associated with their former continental connections. Especially is this the case with the slugs. As the sea forms an impassable barrier to slugs, being deadly both to themselves and their eggs, the occurrence of the same species on an island and the adjoining mainland proves that these were formerly connected by land."

"The great genus *Arion* undoubtedly had its origin in South-Western Europe. Most of the species are still confined to the Spanish Peninsula; and if we proceed south, east, or north, the number of species gradually decreases, and outside Europe and Northern Africa the genus is quite unknown." (p. 480.)

Range of the Red Deer (Cervus elaphus) and its varieties.—"The red deer as a species has probably reached Ireland from South-Western Europe. Not that I would place its centre of origin in that part of the world, for it almost certainly originated in Asia, but that geographical conditions at the time of its migrations to Europe were such that it had no proper means of spreading over the central and northern portions except from that particular region.

"In tracing the present range of the red deer, we have to bear in mind that there are a number of forms very closely allied to *Cervus elaphus*, viz., *C. Canadensis*, *C. maral*, *C. Corsicanus*, *C. barbarus*, *C. Cashmerianus*, *C. affinis*, *C. eustephanus*, and *C. xanthopygus*. Sir Victor Brooke has already referred to the fact that the antlers of *C. eustephanus* cannot be distinguished from those of *C. Canadensis*. A great similarity is said by Professor Nehring to exist between many of the antlers found in European Post-Glacial deposits and the recent antlers of *C. Canadensis*; and he is inclined to refer them, along with the large-antlered Asiatic *C. eustephanus*, *C. xanthopygus*, etc., to the same species, and with this view Professor Woldrich agrees. Then, again, *C. maral* is looked upon as

a variety of *C. Canadensis*, and identical with *C. eustephanus* and *C. xanthopygus*, by Tcherski; and there can be no doubt as to the specific identity with *C. elaphus* of *C. Corsicanus* and *C. barbarus*.

"It seems altogether probable that all these forms are but races or varieties of the red deer (*C. elaphus*). However, in the shape of the antler, we can separate two groups—one with short and the other with long and powerful ones. The former inhabits Northern Africa, the Mediterranean islands, Ireland, and Western Europe generally, graduating towards the east into the larger form, which occurs in Asia, North America, the Crimea, and in the Caucasus, but is now practically extinct in other parts of Europe." (p. 483.)

Fossil Evidence of the Red Deer.—"I may mention that we have fossil evidence of the great antiquity in Europe of the small race of the red deer. It was found associated in Malta with the pigmy hippopotamus and an extinct elephant, and has been obtained in caves at Gibraltar, in Spain, and in Ireland. All the animals of the southern migration, which I have referred to in the preceding pages, formed part of an exceedingly ancient stream which issued forth from South-Western Europe. As I indicated, they did not all originate there, but the natives of that region were joined by those of Central and Southern Asia, which had wandered to South-Western Europe, across ancient land-connections, by way of Greece, Sicily, and North-West Africa. That the fauna of North-West Africa had come from Europe, and that the latter was not stocked from Africa, has already been maintained by the great palæontologist Rütimeyer and by Bourguignat."

Advance of the Asiatic stream of Southern Migration into Central Europe.—"Owing to the breaking up of old land-connections across the Mediterranean, and to the disappearance of barriers in other places, the Asiatic stream of the southern migration entered Central Europe by a more direct route than before, and was now joined by animals of Central European origin in its northern course. The south-western animals and plants ceased to migrate north, possibly owing to a refrigeration by slow degrees of the climate, and at the present moment many of the members of that early migration, which reached Ireland, have become extinct; most of the survivors, still holding their ground in gradually decreasing numbers, discontinue to spread. The older members of the southern migration are therefore in Ireland more or less confined to the south-western counties. Not only are they there in a climate more in accordance with their original habitat, but what is of more importance, the struggle for existence is less keen there, as comparatively few of the latter immigrants from Southern and Central Europe have penetrated to that part of Ireland. It must be remembered that these changes went on very gradually, step by step. Though the number of the south-western species that migrated north probably grew less as the more eastern forms increased, there can be no doubt that some continued to advance north even after Ireland was separated from England." (p. 485.)

Probable Date of the Separation of Ireland from England.—"If, as I think, it may be taken as an established fact that the south-western branch of the southern migration is the first, and the Siberian migration the last, which reached the British Islands, Ireland must have become disconnected from England during the period intervening between the two. It was, therefore, at the time while the migration from Southern and Central Europe was in progress, that the old land-connection uniting the two countries was severed. That migration, however, did not stop when the Siberian animals invaded Europe. Again, we find the southern forms joining in with those of totally different origin in their wanderings, just as the south-western fauna and flora joined with the Central European. We still have confined to South-Eastern England many of the latest immigrants from Central Europe, such as *Helix pomatia*, *H. carthusiana*, *H. cantiana*, *Buliminus montanus*, and others. A large number of species of plants might be mentioned, and also animals from almost all the groups of terrestrial Invertebrates, which apparently had only reached England before it became disconnected from France, and which are still more or less confined to the south-eastern parts of that country. The majority of these are of Central or South-Eastern European origin.

"Of the Invertebrates we have little or no palæontological proof of the period of their migration to England. But with the Mammals it is very different. We know that the vanguard of the Siberian migration reached England at the time when the Forest-bed was deposited. Every geologist is acquainted also with the fact of the extraordinary mixture of Siberian and southern types of Mammals contained in this bed, as well as in the succeeding Pleistocene ones, and that it has been established beyond a doubt that they must have then lived together, though their original homes often were situated thousands of miles from one another." (p. 486.)

Influence of the Glacial Period on the Climate, and on the Fauna and Flora.—"Whether the destruction of the fauna and flora was caused by ice or water matters little. Almost all British geologists and zoologists are agreed that the bulk of the Irish fauna and flora migrated to Ireland after the Glacial period, because they are somehow or other convinced that it must have been destroyed had it reached the country before that period. I have mentioned before that I do not share these views, and I have shown that the range of species within the British Islands is incompatible with the notion of a repopulation after the Glacial period. 'There are few points,' says Professor J. Geikie, 'we can be more sure of than this, that since the close of the Glacial epoch — since the deposition of the clays with Arctic shells and the *Saxicava* sands— there have been no great oscillations, but only a *gradual amelioration* of climate. It is *quite impossible* to believe that any warm period could have intervened between the last Arctic and the present temperate conditions, without leaving some notable evidence

in the superficial deposits of Scotland, Scandinavia, and North America.' In the same way, I think, there are few points we can be more sure of than that the South-Western European fauna and flora in the British Islands are more ancient than the Siberian or the Arctic. If Professor James Geikie were right, it ought certainly to be the other way round. But the evidence as to the climate in the British Islands during the Glacial period is so contradictory, the very nature of that period is so complex, that few scientific subjects during this century have raised more angry discussions, and none have produced a vaster amount of literature. That I should help to increase the latter still more is to be regretted, especially as the subject is not my own, but having been led by faunistic evidence to regard this vexed problem from a side from which it has hitherto received but little attention, I hope I may be excused for venturing to add my own views to those already known." (p. 488.)

The author, after citing the distribution of four species of *Helix*, belonging to the subgenus *Xerophila*, which are spread over almost the whole of Ireland, *except* in the extreme south-west portion, proceeds as follows:—"That the whole Irish fauna and flora could have survived on a now sunken southern extension of Ireland, is, therefore, impossible. They must have remained within the present boundaries of the island during the Glacial period, though it is probable that it did extend somewhat more to the west, south, and north than it does now, and that those parts of the country stood at a relatively higher level to the east; so that the Shannon and some other rivers, which now drain into the Atlantic, emptied their waters into the Irish Sea.

"The nature of the Pleistocene Mammalia of Eastern England is not such as to indicate an Arctic climate in the British Islands. The presence of northern forms is due, as we have seen, to an immigration of Siberian animals; but, as they lived in company with southern types, many of which required an abundance of green food, the winter temperature in the British Islands may have been as high or higher than it is now, though with a lower summer temperature, and with a copious snowfall in winter, glaciers were generated in the mountainous regions. A number of land and fresh-water shells are quoted by Professor J. Geikie from the Arctic fresh-water bed on the coast of Norfolk, in evidence of a rigorous climate. These are spoken of by him as high northern forms; but in this he is mistaken. Every one of them are inhabitants of Ireland at present, and all but one are very common.

"But if the fauna does not indicate Arctic conditions during the Pleistocene epoch in the British Islands, we are told that what is known of the flora, at any rate, is such as to exclude the possibility of its existing under anything but an Arctic climate. The same Arctic fresh-water bed just referred to contains, besides the shells, some plant-remains, and these, according to Mr. C. Reid, imply a lowering of the temperature by about 20° F. Yet

the plants of the Forest-bed, Mr. Clement Reid tells us, are not Arctic, and although the land and fresh-water molluscan fauna remains much the same in the later deposits, the plants alone, it appears, are quoted as indicators of temperature." (p. 492.)

"It seems to me probable that the extensive migration of Alpine and Arctic plants, which undoubtedly took place in past ages, did occur long before the Glacial period, during a milder and more equable epoch, and that they have since become adapted to live in countries where they receive sufficient moisture during summer, and are protected from severe frost in the winter by a cover of snow.

"I believe that neither the animals nor the plants which have been discovered in British Pleistocene strata indicate the presence of an Arctic climate in the British Islands during the so-called 'Ice Age.' The theory of a general glaciation of these Islands — the South of England excepted—has, however, been so universally accepted by geologists, that it has almost passed the stage of controversy, and is more generally regarded as an established fact. I am not sure whether even those who are in favour of the view of the marine origin of the Boulder-clay, disbelieve in a previous general glaciation. Yet it is not long ago that the generally accepted view was that all the phenomena now attributed to land-ice had been produced by the action of floating icebergs. The rock-scorings, 'crag and tail,' boulder-clay, scratched stones and drumlins, were all believed to be due to the action of the sea, assisted by floating-ice.

"I will not, however, venture to discuss this extremely intricate subject of land-ice *versus* floating-ice; and hope that geologists may think fit to reconsider their final verdict in the light of the conclusions I have arrived at from a study of the geographical distribution of animals.

"There is one factor of importance in connection with this theory of an ice-sheet which may throw some light on the subject, and that is, the configuration of Ireland during the Glacial period. Mr. Close remarks: 'Some sufficient increase of relative height towards the west or WSW., with a corresponding extension of the land in that direction, is required, if we are to account for the general glaciation of Ireland by the movements of a universal ice-covering formed upon her own surface'; whilst Professor Bonney seems to think that the coast margin in the earlier part of the Glacial period may have roughly corresponded with the present hundred-fathom line. The land-connection between Scandinavia, Scotland, and Ireland, formed, as we have seen, a highway for the migration of the Arctic animals and plants. When the lowlands of Ireland were covered by the sea, which event, I presume, happened some time during the Glacial period, a broad belt of land probably remained separating the Atlantic from this westward extension of the Irish Sea."

Suggested Marine Origin of the Boulder-clay.—"The Boulder-clay, which covers such vast tracts of country in the British Islands and the Continent, is now generally believed to be the ground-moraine

of huge glaciers, but I am inclined to think there is equally strong evidence in favour of its marine origin. Shells of Mollusca and Foraminifera are very frequently present, especially in Ireland, and a remarkable number of species have been identified in that country by Messrs. Praeger and Wright, though the specimens, as a rule, occur in a broken condition. When we consider that the clay in which the shells lived has probably been subjected to considerable movements, it is not surprising that they should be in a fragmentary condition, and that shore forms should often be found mixed with those inhabiting deeper water.

"It is probable that before the Glacial period began, a warm current, not necessarily the Gulf Stream, supplied the Arctic Ocean with warmth. The cessation of this current gave the first impetus to the formation of ice near the North Pole, the Arctic Ocean being then a closed basin. Two extensive transgressions of the Arctic Ocean now took place, one inundating the plains of Arctic America and the other those of Northern Russia. The latter transgression covered a portion of Northern Continental Europe, and joined the great inland sea, the Ponto-Caspian, by some narrow channels, so that Asia became almost isolated from Europe. The Siberian fauna was, therefore, unable to migrate to Europe, but a number of Asiatic mammals invaded North America, which was accessible by means of a land-passage across Behring Straits. Meanwhile, Arctic marine species found their way to Northern Germany, and to the western portion of the newly-formed North European sea, now the German Ocean.

"The first occurrence of Arctic forms of life in the newer Tertiary deposits on the east coast of England, marks therefore the period when this marine transgression took place, the German Ocean being at that time closed on all sides, except to the east. As Arctic marine species make their first appearance in these English strata in the newer Crags, the latter are synchronous with the Lower Continental Boulder-clay, in which these same species are first met with. This reasoning might be found fault with, but the vast immigration into Europe of Siberian mammals took place after the deposition of the Lower Continental Boulder-clay, during the so-called Interglacial phase of the Glacial period. Now, as the advance-guard of this migration reached England during the time when the Forest-bed was laid down, the supposition of the contemporaneousness of the newer Crags with the Lower Continental Boulder-clay seems to me correct. There is no reason to suppose that the Interglacial era or Forest-bed period was characterized by a much milder climate than that preceding it, but, as it was probably much drier, the glaciers which had formed on the Alps and in Scandinavia receded considerably. The immediate result was a diminution in the amount of detritus carried to the North European sea by icebergs, so that more extensive colonies of marine animals were able to establish themselves on the sea-floor than during the preceding stage of the Glacial period. The narrow straits which had formed across the Tchernosjem district

in Central Russia, between the Northern Sea and the greatly enlarged Caspian, ceased to exist in the Interglacial phase, owing to the gradual withdrawal of the Arctic waters from Northern Europe. A slight refrigeration of the Siberian climate was the consequence, and the barrier which prevented egress to Europe being now removed, the Northern Asiatic fauna swarmed across the plains of the newly-opened continent.

"During all this time, Scandinavia remained connected in the north with Greenland, and in the south and west with Scotland and Ireland, but it had no direct communication with the continent, being separated from it by the North European sea. England and France were united throughout the Glacial period, but the connection between the former and Ireland broke down during, or shortly after, the deposition of the Forest-bed, so that none of the Siberian migrants, which now poured into England from the Continent, reached Ireland." (p. 496.)

"It seems to me that the theory of the marine origin of the Boulder-clay offers the following simple explanation:—After the Interglacial phase of the Glacial period had passed away, a renewed transgression of the Arctic waters must have occurred, but the sea did not again invade Central Russia. As Professor J. Geikie has pointed out, the erratics included in the Upper Boulder-clay of Northern Continental Europe have travelled in a different direction from those contained in the Lower. A change of current, therefore, evidently took place owing to the fact that the Northern European sea was not now connected with the Ponto-Caspian basin.[1]

"A large number of erratics would therefore be brought by Scandinavian icebergs stranding on the east coast of England, which was gradually being submerged by the advancing marine transgression. As the water rose, the local glaciers which had begun to form on the mountains of the North of England and Scotland, cast off icebergs which scattered detritus and boulders over the plain." (p. 497.)

"I think the marine theory would explain in a more satisfactory manner than the terrestrial one, the fact of the erratics being carried in a direction contrary to the natural flow of a glacier, if we remember that probably a strong current existed from the more or less closed North European sea to the open Atlantic. The occurrence in almost all the English Boulder-clays of marine shells tells strongly in favour of the view that these clays are of marine origin. Moreover, they are found to contain Arctic species, and these are mixed with southern forms as we approach the land adjoining the Atlantic, where an almost purely Mediterranean fauna had hitherto existed. Arctic forms of life now found their way, not only into the Atlantic, but by the newly-opened Straits of Gibraltar they entered the Mediterranean, and are preserved to us in some remarkable deposits in Sicily." (p. 500.)

"I think Mr. Praeger's conclusions as to the changes in the

[1] This, again, is of great importance in establishing the contemporaneousness of the Upper Continental Boulder-clay with the whole of the British clays.

marine fauna of the north-east of Ireland agree in the main points with those which I arrived at from an independent inquiry into the origin of the terrestrial fauna of that island.

"From the careful study of terrestrial faunas, has been gained not only the knowledge of the changes of climate which have passed over the world, but, in the main, those geographical revolutions which have been produced in North Europe in recent geological times. I trust that I have succeeded in strengthening the old Lyellian theory on the origin of the Glacial period, which has received such strong support from no less an authority than Lord Kelvin."

CORRESPONDENCE.

TRINUCLEUS SETICORNIS.

Sir,—It is interesting to read two remarks occurring in successive numbers of your Magazine. In the August number (p. 379) I wrote: "If Mr. Reed will turn to my Sedgwick Essay . . . . (published in 1883) . . . . he will find *Trinucleus seticornis* recorded as a Middle Bala fossil in North Wales, the Lake District, and Scandinavia, and nowhere recorded in the Upper Bala list."

In the September number (p. 427) Mr. F. R. C. Reed writes: "He [Mr. Marr] mentions in his criticism of my remarks that in 1883 he had stated that this species was nowhere found in the Upper Bala."

I nowhere mention that I have made this statement, and I never did make it. In 1883 *Trinucleus seticornis* had not been discovered in beds recognized as Upper Bala, and naturally I could not record it, but made no statement concerning its absence in Upper Bala rocks. In 1885 it had been discovered, and the discovery was then mentioned by Mr. Roberts and myself. Mr. Reed accuses me of a mistake, because in 1883 I did not record an undiscovered fossil! He ignores the essential point of my letter that *Trinucleus seticornis*, which he states (Q.J.G.S., vol. liii, p. 90) to be a characteristic Upper Bala fossil, is abundant in the Middle Bala beds. J. E. Marr.

Cambridge, *September* 23, 1897.

MISCELLANEOUS.

The Forest-Bed of the Norfolk Coast. — This interesting deposit, so rich in organic remains, has been carefully worked for more than twenty years by Mr. A. C. Savin, of Cromer, who during that period had accumulated about 1,900 specimens of Vertebrata, many of which had been described and figured by Mr. E. T. Newton, F.R.S., Prof. Leith Adams, Prof. Lankester, F.R.S., and others. Mr. Savin's collection has just been acquired by the British Museum (Natural History), where it will be preserved for all time, and form a most unique and valuable addition to our National Museum, as well as add greatly to our knowledge of the fauna of this old Pliocene land-surface.